ActInf Livestream #037 ~ "Free Energy: A User's Guide"

Group discussion of the 2021 paper "*Free Energy: A User's Guide*" by Stephen Francis Mann, Ross Pain, and Michael Kirchoff.

http://philsci-archive.pitt.edu/19961/

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Session 037.0, January 28, 2022

https://www.youtube.com/watch?v=chpbMBgDR84

An introduction for some of the ideas in the paper.

SESSION SPEAKERS

Daniel Ari Friedman, Stephan Sillett, Dean Tickles

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TRANSCRIPT

00:31 DANIEL FRIEDMAN:
All right, it's January 28, 2022, and we're here in ActInf Lab livestream number 37.0, discussing the paper “Free Energy: A User’s Guide.” Welcome to the ActInf Lab. We area participatory online lab that is communicating, learning, and practicing applied Active Inference. You can find us at the links here. This is recorded in an archived livestream, so please provide us with feedback so we can improve our work.
00:58 All backgrounds and perspectives are welcome here and we'll be following good etiquette on livestream. Go to ActiveInference.org if you want to learn more about anything happening at ActInf Lab. All right, so today in 37.0, we are going to learn and discuss and introduce and provide some background for this paper, “Free Energy: A User's Guide” by Stephen Francis Mann, Ross Pain, and Michael Kirchhoff. And just like all the dot zeros and discussions, we're just going to introduce some ideas, give a little tip of the iceberg, and kind of warm up to talk about this paper in the coming two weeks.
01:40 And so today we'll be going through a lot of the background and some of the key formalisms in the paper. And the coming two weeks we'll be discussing the paper. So let us know if you want to join. So first there's this comment in red. Is this your steam?

01:55 DEAN TICKLES/Daniel:
Yeah.
Pardon me? Do you want to describe it here or in your intro?

Yeah, in the intro.

Great. All right, well, we'll each just go around and say hello, and then I think we can just say one reason why we're excited to discuss it.

02:13 Daniel:
I'm Daniel. I'm in California and was just enticed by the title Short and Direct. And I think it has some

great solidifications and perspective and implications on multiple levels. So how about Steven?

02:30 STEPHEN SILLETT:
Hello, I'm Steven. I'm based in Toronto. I was interested by another sort of way to surmise the free energy principle and Active Inference type approaches in relation to the philosophy of biology and cognition science. I thought that was interesting to see how that pitch was being made open to Dean.

02:56 Dean:
Hi, I'm Dean. I'm in Calgary, and anytime I see the word guide, I'm always curious because of my background in setting up programming where people were going into novel operating point.
03:10 The authors kind of had me at that word, and then I wanted to sort of learn more about what they had to say. What are some key features of guides or things that guide should keep in mind before we head off on this journey? Yeah, well, for me, I've sort of adopted the term wayfinding kind of as a blanket, not just a Markov of blanket, but as a way of maybe describing what that path could turn out to be without necessarily constraining people. I'm sure there are other descriptions and definitions of the word guide, but that's the one I tend to gravitate towards. All right, Steven.

03:53 Stephen:
Yeah. And there's also what kind of guide we end up inhabiting so this biological grounding, it feels like there's a desire to get into our feet and Hinton the soil somehow, as well as the cognitive science. So I feel it's a little bit like I've been stretched up and pushed down into the ground. So something there. Okay, so one big question, probably not the only big question that could be raised, Bit, just the question that approached us to this paper in some way is how can we learn and apply an active inference?

04:32 Daniel:
And then, Dean, do you want to talk about what you role here? I just like to kind of read it out. Yes. Okay. So assuming that making moves which we could describe as behavior now has set on what happens next.

04:48 Dean:
And that those moves are at least loosely based or inferred on evident. And the authors use the terms probabilities. Prediction. And fitness so that's in the paper. Then how might we begin to look at energy applied in calculating out our best guess is measurable as or of what we think we believe will happen next step on that road through prediction matter expertise.
05:13 Now, prediction matter expertise is a term I coined and brought up switch Karl Friston. But I think Bit might as we're diving, we might think about that in the background. The other part was they talk about models, and in our last livestream set, that's all we're doing is talk about modeling ourselves. So it seems like a natural extension now to talk about models, models as inference and action, models as selection, models as extenders I e tools. And then how does a model curate curated rundown help us

get outside the guide when using energy in ways beyond guide exploration and interpretation?
05:55 Do we need a user's guide for the user's guide, which was something Zhat I used to ask all the time, the kids that were participating in the program that I was setting up, because they were going out with their background and they had sponsors who had a different background. And we often wondered whether or not they would have to give a user's guide to somebody who is necessarily more experienced with the field, but not necessarily experienced with bringing young personal on. So that's why I think that when we're talking about how can we learn and apply inference in this guide theme, those are things we might want to keep sort of at least partially in our thinking. Thanks a lot for sharing that, Dean. A lot to say.

06:38 Daniel:
But that's what the dot one and the dot two and beyond are for. So the paper is Free Energy a User's Guide by Stephen Francis Mann, Ross Pain, and Michael Kirchhoff. It's from the last days of 21, I believe, and it is on the philosophy archive. Okay, so here are some of the aims and the claims of the paper. Over the past 15 years, a novel explanatory framework spearheaded by Karl Friston has inspired both excitement and confusion of philosophy, of biology and cognitive science.
07:12 Active inference, whose most famous tenant is the free energy principle, purports to unify explanations in biology and cognitive science under a single class of mathematical models. So not math under biology, but biology under math. There are broadly three reasons why the active inference framework is difficult to understand in the author's words. First, the mathematics area, unfamiliar to many philosophy and even to biologists and cognitive scientists and mathematicians and all other kinds of peoples. Second, the framework was developed rapidly by a small but dedicated group of researchers, limiting its accessibility while expanding its scope, hashtag recent history.
07:59 Third, the framework makes claims across both mathematical and empirical domains, and the dialectical relationships between phase are unclear. So what is the math biodialctic who's nested within who? Yes, Steven? Yeah, I think the way these three kind of points are made is useful for seeing the rationale for this paper. I think there's seen as a desire to come at these questions as if it was coming from people less steeped in all the math, because previous papers might have come out which had an awful lot of particular information that comes from this dedicated group of researchers.

08:51 Stephen:
I think by trying to speak about it from the perspective of people arriving. It gives those core researches which I know official Michael Kirchhoff has been part of a chance to clarify the sort of framings or misconceptions that might end up being placed in other papers by philosophy and I think has become a little bit of a vicious cycle of distraction at times. And I think they may be trying to reclaim that ground. So that's just my own strategic guess, but it looks like that might be why this paper's been put together. Cell great and helpful feedback.

09:37 Daniel:
Thank you. Then the last parts are here. We attempt to redress this situation by targeting each source of potential confusion. So they're going to identify three frequently asked questions, frequently raised

concepts underpinning frictions, and then redress them. And their aim is overall, we aim to increase the philosophy understanding of active inference.
10:00 So zhat it may be more readily evaluated, and maybe we could even add applied and developed. Okay, so would either of you like to just read the abstract? I'll go thought bit. Okay. Over the past 15 years, an ambitious explanatory framework has been proposed to unify the exploration across biology and cognitive science act of inference, whose most famous tenant is the free energy principle that's inspired excitement and confusion and equal measure.

10:30 Dean:
Yes, it has. We lay the groundwork for proper critical analysis of active inference in three ways. First, we give simplified versions of its core mathematical models. Second, we outline the historical development of active inference and its relationship to order theoretical approaches. And third, we describe three different kinds of claim labeled mathematical, empirical in general, routinely made by proponents of the framework and suggest dialectical links between them overall, we need to increase philosophy understanding of active inferences so that it may be more readily evaluated.

11:08 Daniel:
Cool. So nice and funny. Abstract. We all laughed. So, the roadmap.
11:14 How do they structure this guide? Is it meant to be read linearly, or do you flip to a different page? I don't know. But we have added the page numbers on this slide. It's on the bottom right, but it'll be on the bottom left.
11:27 And that's what page we area in the guide as if it were in paper in our hands. And it starts with an overview. And then there's a discussion on, first the inference of perception or observation in hidden states. And then action comes into the loop. Section three gives a brief history of the free energy principle.
11:49 And section four discusses the aforementioned dialectic of free energy and its rhetorical ecosystem. We could say that's the part we're not going to focus on in this zero, but hopefully we're going to be able to go into each of these really important troikas in the dot one and two. Then there are some concluding remarks. Okay, so first, how is the word model being used here? It's really good that the authors included this warning because we hear about modeling all the time, not just the photography kind, the mathematical kind.
12:25 So they write, let us begin with a warning. The word model takes on two distinct senses throughout our discussion. The sense, more familiar to philosophers, is what we call a scientific model, a representation of some possible or actual system which a scientist uses to reason about or discover features of that system and related systems. By contrast, in the active inference literature, a narrower sense is typically meant what we will cell a generative model. That's what we're going to be specifically talking about.
12:59 This is a mathematical object with applications in statistics and various sciences. Our simplified models of the free energy principle are scientific models. So models is a big category, but we're going to be talking about kind of a narrow sense of statistical model, like linear regression models. But instead of a linear regression, it's a different kind of model, not at the exact same selection of the linear model or taxonomy, but like in that category. And then note further that some scholars opt for a

deflationary stance on generative models, using them only to describe the dynamics of agents.
13:38 So, descriptive modeling, it is an open question whether this kind of model building precludes any form of scientific realism about the relation between the model and the target system. These issues are discussed in section four and also have come up several times, including with most recently Majid Beni but model based science and what does it mean to use and make models and maps and territories and all of that. So any thoughts on model? Because that's going to be one of the key terms going forward. What would either of you say would be the best way in layman's terms to show the inference between what they mean when they talk about an empirical model and what theory talk about in terms of a generative model.

14:27 Dean:
What sort of real physical material things could we use to make clear the difference? Because in the last stream we did a good job of taking columns and showing how they were discrete. How would you guys describe this? Yes, Steven?

14:44 Stephen:
I think one of the ways this distinction comes about is the difference between most system type approaches and nonlinear dynamical systems. And generative models are encoding to be coming from swarming like a swarm of bees creating and evolving as compared to something which is being given a perspective and drawn out somehow in our environment as in a scientific model. Now, the fact that generative model. Model are being applied in the kind of scientific way inverted, commas or are they being are they being used in a more instrumental stroke philosophical way and they can never be fully science is another question. But I think the difference there between this kind of biological generative sort of process and something which can be given a perspective on and drawn out as a defined type of model is where there's a kind of a clear difference. I don't know how others see that, but I think Zhat also might be useful.

16:11 Daniel:
All right, Dean, here's my answer would be two that are on the extreme end of the yellow type. Scientific model would be like the standard model in physics or a working model of renal function like kidney function. So it's like very transdisciplinary and includes a huge number of domains and kind of like logical motifs and AZ axioms and a specific history and software toolkits and all of that. And then we're going to be talking about a kind of model that's basically a parametric statistical model. So like a Gaussian model takes two parameters, the mean and the variance.
16:50 And that can be written analytically like with equations or can be done computational but it's only ever gain to take those two parameters and it only ever outputs a certain family of distinctions. And so it's like parameters in, distinctions out and the parameters can reflect on the connectedness of a graphical model too, but you get parameters in which can include model structure and then some type of output. But it's close ended within that paradigm versus the model of renal function is like this open ended question. I think you hit on something reality critical. There is distinctions out.

17:30 Dean:
So something falls out when we're talking about a generative model. Whereas when we're talking about something empirical we tend to keep the focus stabilized. Right? So the process is fundamentally different. And so again, when we're talking about in sort of layman's terms what the difference would be, I think the key word of Zhat, which is something that's in and stays in versus something that may start in one place and fall out in a completely different place.
18:02 Is that an expectation we should have as a difference between these two? Yeah, just one thought then, stephen would be both modes are so important. It's like Yin Zhang or left and right hand or clubs and concave. And our discussions do move regime of attention from like the generative model to the bigger question. And in some ways it maps onto instrumentalism and realism too.
18:25 Daniel:
But we really need to know when the pendulum is swung one way and when it's swung the other way. And so we can keep an open mind and they're all happening all the time that both eyes open, like you're always saying. Dean but we also can't go too hard on just one side. Steven yeah. I love what you said theorem, Daniel, about the axioms.
18:50 Stephen:
I think generally in science you try and have reproducibility and you have tolerances and you say how much accuracy and what the coherence on something? But there's a general recapitulation of similar types of results again and again and again and the same sort of thing comes up, has been there in psychiatry and psychology. And that's where the idea of syndromes being classified as opposed to symptoms, which must be much more fluctuating, more variable. So you could run a generative model and it can come up with different results with the same input. Now, there will be some kind of characteristic patterns that generative models do reveal, but there is a point where it's quite different.
19:40 And I suppose when that difference, I think it's almost paradigm Bayesian inference, but maybe there is some point where they blur, I don't know. Yes. Dean and then we'll go onto the paper. Yeah. So at the end of the last livestream, one of the comments that one of our colleagues Blei made was that we have to be able to hold two things up at once, which sang to me because I think that's what you're saying both of you are saying right now.
20:05 Dean:
I think if we look at whether we're looking at a starling agent or a perturbation, whether we're looking at an ant or a colony, we can keep something in inbound or we can have something fall out from that because it's basic research, like we weren't expecting something repeatable. That's how I would distinguish it. But again, let's get onto the paper. But I think that's important that we get that established first. If we're talking about guidance, that was.
20:37 Daniel:
The big epistemic disclaimer and that's what they put in their paper. So we allocate our attention as well. Okay, so on to the details of the paper. So in two two they introduce this simple model of inference with W and x. So this is figure one.
20:56 There's W for world, that's the hidden world state. And then there's x, the observed data. Like x marks the data and you can think about like where do you estimate where the sun is in the sky that's actually unobserved. But then there's going to be all kinds of observed data coming in or we'll talk more about the coming in versus the generative model later. But the observed data are what are being

modeled as being observed in that sort of sensory way.
21:24 So figure one is the basic model of inference, the inference problem addressed by the active reference trajectory. What other kinds of inference problems exist, what problems do or don't have this form? What happens if there's no line with W and x? So of course it can get more elaborate but within this exact format, like W might output x and y and that would be like getting two numbers back in the computer program instead of we're generating two numbers in the computer program rather than just returning one. Or you can imagine x is like a vector.
21:58 But we're within that specific model framework. We're not in the realism of agent environment, we're just in the statistical framework of hidden latent variable observable variable x. The unobservable state is assumed to cause observable data. And so this is a little bit of a connection with dynamic causal modeling because statistically we call that causing just like the proportion of variance explained by a PCA, it's like given very active terms but it's actually not causal in the mechanistic sense. And that of course has been to no end of confusion with how statistical conclusions are interpreted as mechanistic conclusions about the world.
22:49 And so is it cause in the sense that we dean it in one sense or is it associated in a causal model and that's kind of the causal and dynamics causal modeling, that's functional connectivity. So that's the realm that we're talking about, not within the world environment interaction. Steven yeah, this is actually interesting. I've gone back to a pre Markov blanket kind of formulism and it raises that question then of what

does it mean to infer? And it can be that we infer things because that's what we get data on.
23:25 Stephen:
So it talks about cell, what is it that we can even use to understand and what are the assumptions about what's actually important to read and those two things. I think this leaves both of those things open and that actually is a bit of a bridge between the scientific and the generative process. Cool. So if we're modeling like height is not measured but we observed weight and we're going to do some regression of like the unobserved and the observed, that is the type of model that we're going to be talking about loosely. And someone could say oh, but this other factor influences too.
24:06 Daniel:
Yes, that's the reality claim. This actually matters in the real world and it very well may, but we're talking about measured modeled relationships. Stephen yeah. I think this is also really helpful to be able to look at paradigms because there's a difference between say the paradigm of psychology from the perspective of looking at classification and problem identification and treatment and coaching psychology. Which is about not so much trying to diagnose what's there.
24:38 Stephen:
But what sort of action someone is trying to take and how you might help them with those actions to reach outcomes which may vary moment to moment. And I think in some ways this is maybe the level you have to go back to because otherwise the noise just swamps the discussion. It goes deep on both ends. That action orientation, the pragmatic turn. Ecological psychology is going to connect deep and this is going to be deep but in a sense narrow because we're just talking about statistics here.
25:14 Daniel:
So take statistics courses and learn it because this is kind of where it comes from here. Okay, on to the example of active inference. That's not actually what they called it, but that's the cat example that we're

going to be discussing. We're going to imagine that you have a cat animal that spends its time in either the kitchen or the bedroom. When it's in the kitchen, it often meows for food.
25:38 When it's in the bedroom, it often purs loudly. Suppose you tally the proportions of the times your cat is in each place and making each noise. The results might look something like, okay, but the cat also goes somewhere else. Okay, not in the model or this other factor or this other sound. Okay, change the model, add another column.
25:59 It's totally fine. It's a force on the GitHub or the discussion. But that's the difference between kind of modifying the model structurally and using it parametrically within the narrowest sense of model and then keeping the discussion alive about that broader sense, like what Steven is talking about, like a model of psychology or a model of complex adaptive systems. So one thing to noise is that this idea of setting the prior in a Bayesian sense from observed data is called parametric empirical parse. So parameter parametric.
26:35 We're setting parameters like frequencies of things happening. And it's empirical which means observed. It doesn't mean like the only truth, it just means the measured values. And then it's Bayesian as we'll talk about. So let's just say ten or 100 or 10,000 measurements were made and they come out to these numbers.
26:52 60% of the time they're in the kitchen and 40% the cat is in the bedroom. And so that's like summing across. That's called a marginal probability because it was in the margins of papers and the marginals have to sum to because something has to happen in the model order. But the cat can be in the roots. Yes, but within the model it has to be this way then that's what makes a probability.
27:21 Then 50% of the time there's meowing and purring. But as the numbers show the location and the sounds, they have a statistical association. There area, some divergence that could be tested for statistical significance depending on the number of observations, but that is what the numbers in this table are reflecting and both columns and rows sum up to a probability. So they're all like proper probabilities.
27:58 Then how do you infer about this? Like, if you were to observe the room, how could you reduce your uncertainty about what sounds you'd hear? And then if you'd hear sounds, how could you reduce your uncertainty about the room? Many philosophers will be familiar with one famous method for solving this problem Bayesian conditionalization. This method can be stated as a principle saying how an agent using a model P of W and X w world state hidden x observed data ought to choose their beliefs.
28:29 Q of w q. That's the one we control upon observing data. X what to believe now conditioned on incoming data. Okay, any points on that? Because they did a really good job of explaining it.
28:45 Dean:
Yeah, I'm waiting for the next slide. Okay, please continue here.
28:52 So from the actual paper, the table describes a joint stability distribution, which we've just explained, where W ranges over possible cat locations, either the kitchen, bedroom and X ranges over the possible cat sounds. Again, very clear, straightforward from the next side. Usually the scientist, not the person who is trying to build a generative model, aims to improve the accuracy of a generative model of some real world phenomenon, which would mean improving the accuracy of PWX. This learning task is relatively difficult. So I wanted to kind of parse what relatively difficult meant, and I'm not going to read all of that stuff there in red.

29:36 But essentially what I plant to kind of state is the authors here said this is simple. Don't go to that place of high complexity quite yet. Let's just see this for what it is. So that what Daniel said 90 seconds ago, which was, go take a bunch of statistics courses. Doesn't have a bunch of people running off and screaming into the night.
30:01 There is a complexity to this, but it's not the kind that will swamp you. What they're basically trying to say is, let's just slowly work our way into this without all your historical grievances around statistics trapping you before you even really set sail. I'll add one note on that. This is like learning how the horse moves in chess or learning how the castle model in chess. And so it's possible to get super connected to your internal life narrative in the game of chess.
30:36 Daniel:
And people who would have no problem losing and connect for or checkers will feel very engaged, emotionally affectively by chess. It's just something I've observed empirically. Somebody else might have different priors on that. And so this is a way of just starting switch how the pieces move. And then, as we're finding out, playing in a fun, we hope, ecosystem and playground and sandbox so we can figure out how the pieces move.
31:02 And then we're going to connect them and do all kinds of fun stuff. Steven. Yeah, I think like you say, having the ability to stay with the pieces, do lots of fun stuff. Look at the way things are generating with that data is different. For instance, to say oh, the meowing cat is an assertive cat and the purring cat is a docile cat, which could be this kind of imposed high water model and then everything is trying to fit to is it a docile cat or is it an assertive cat?
31:33 Stephen:
But it's flattened out. All of this loses this stability to generate.
31:42 Daniel:
Professor Helen longau has a book called Studying Human Behavior and Aggression in 2010. That's like once you define there's a significance difference between these two groups or in the count of this behavior per minute and they've been pre labeled, it passes the modeling in the broad sense into modeling into the narrow sense. We found a difference between the groups. So this is reifying our understanding of those categories. So it's really important.
32:13 So this is going to be where the base enters the picture, the posterior, which means afterwards is calculated about how should the distribution P be updated as new information comes in. So just like the last sentence and read what's to believe now conditioned on incoming data. So now that is going to be symbolically or graphically described. So probability the P distribution of world states conditioned on vertical line new data coming in. And there's Bayes theorem, other videos and other channels and groups will cover Bayes better and more comprehensively.
32:59 But here we can suffice to say that first we can write it in words like what's the distribution Q that we control the probability distribution of us thinking that it's in the kitchen. That is the prior probability of it being in the kitchen or condition on it meowing. So how likely is it to be given that it meowed and then the numbers that we just looked at can be plugged into that verbal equation and a numbers is going to come out. And so we heard meowing. If we just looked at meowing like four times in the kitchen, one time in the bedroom.
33:37 So four to five times it was in the kitchen, not the bedroom. And then here's an equation that does literally that it just looks at the column and it does the conditional likelihood or the posterior of the

world's day after the data come in.
33:57 Did anyone want to say anything here? There's this learning task is difficult. I think we already kind of mentioned Zhat. And the whole thing is that most people I think I'm not going to say philosophy, most people don't automatically go to being able to figure out what the probability is. But I think what these authors are pointing out is there's a way of being able to show that there is a probability in play if you are not certain.
34:27 Dean:
And this is how you might split those. Probabilities out. That's all they're trying to do. Okay, so now we're going to go from, as we've seen in other papers, the sort of exact Bayesian approach. Most similar paper to this in this sense is probably axial constants number 34 with the bacterium.
34:48 Daniel:
We first looked at the Bayesian bacterium and then we looked at the variational Bayesian bacterium. And then in both cases we looked at how basically sometimes new data could come in and you could still make wrong decisions. Whether you're doing exact bays or variational inference, you can still make bad decisions as data come in. So this isn't a Penguochian paradigm. This is like a statistical tool that's already been detached from the philosophy or at least sort of docked at shore.
35:18 And then now also we're breaking the assumption that it must go the right way or that it will model real world system especially. So gain back within the narrow sense. Sometimes the specific distribution of the world states conditioned on data coming in is intractable, so that distribution cannot be calculated. This usually happens when the state space is continuous rather than discrete, which came up on model stream number 5.1. If there's only two decisions left and right, all you have to do is do two calculations and then compare which one is preferable.
35:53 Whereas if there's a steering wheel or a trim tab, then there's an open ended number, because 87.1 degrees and 87.1 degrees might be very different in their longterm consequences. So continuous state spaces are very challenging from a sensory as well as from an action perspective. In these cases, what is needed is a way to choose Q of W, the distribution we control on the world state, to make it close to P of W recognition model x. So real estate's condition on data is the hard one to compute exactly. And this is going to be choosing a distribution that gets close to that other one.
36:34 When the problem is formulated by statisticians, we usually begin with a family of possible distinctions Q and search for the member of that family which lies as close to PW condition on X as possible. So just like a linear model, it's like condition on this being a linear model, we're going to find the best linear model or condition on the quadratic form we're gain to find the best quadratic form. This is like a little bit more general conditioned on the family that Q is. We're going to do basically linear regression fitting, but not exactly linear regression. How do you make those distributions converge or align as best as possible?
37:14 We can do this also, given that a structure has been chosen, this is the fitting part. This is not the structure learning unless the parameters about structure. We can do this indirectly by using a measure of inaccuracy. Active inference employs a measure of inaccuracy called variational free energy labeled F because it is a measure of inaccuracy. Smaller values are better than larger values.
37:37 So it's like Frisbee golf and the lower the value is, the lower the difference is between the actual P that you would have calculated perfectly and Q the way simpler lower dimension model that you can control and can save in Ram. So that's described here. Variational free energy captures two sources of

inaccuracy that we're going to go into in the next slides in belief and dictates how they ought to be traded off against one another. The two sources which we're going to explore are overfitting and failing to explain the data. So those will be introduced and discussed soon.
38:14 Steven. Yeah, I think this also if we're just to connect it to that scientific standard models and this type of work is this is looking at contextuality. It's like what based on where the starting point is that the probabilities area being picked up on, you start to roll out the statistical results. What sort of meowing is actually happening? And as opposed to a model where you're modeling a car engine and you want to know what energy is going to give out a particular moment, it's going to do that whether I'm watching it or not.
38:56 Stephen:
It's just the same basic model applies independent of the observer. So I think that's also useful here. Yes, like getting the model to this stage, like depersonalizes it in a sense because that model can be just transferred and used in another instrument. Okay, so here's those two sources of inaccuracy that they described. The first that we're going to discuss is overfitting.
39:22 Daniel:
The cost of overfitting, they write, can therefore be measured by checking how far Q, the one we control on world states, diverges from P. The first term of F. Free energy is a measure of that kind. This expression too is also called the reflective entropy or holdback library or the KL divergence. So this is like the first half of the two part equation that will constitute F.
39:52 And it looks like this graphically, symbolically. But here's a kind of cool way to think about it. If you were trying to fit a single hump to this two hump model in the empirical distribution. So you're fitting a family that is going to get sort of coerced into one of two extremes. Either it's going to end up fitting one very closely like the higher one, if it's like mode seeking and it will have no probability density the Bleu line onto the other hump, or it will conflate them in a sense into two kind of sub operations blurred together and have a solution basically that kind of goes between them.
40:40 Kale emergence is a way to fit distributions optimally. Given this kind of challenge, which exists for the one hump fitting two hump, it exists for the two hump fitting three. It exists for the one fitting 50. It's a general statistical problem. And KL is a method that helps bring that Bleu line as well as it can on a trade off frontier into alignment with the black one.
41:09 Okay, steven? Yeah. I suppose this also gets into the reason when this is useful is when you're in complex nonequilibrium situations where things are fluid, then you're gain to hit these situations and overfitting is quite common. Social science has been one of the areas where we see these problems where it's equilibrium based and it's fairly clear then you don't really have it's not really as applicable. So it sort of speaks to where this type of approach is applicable.
41:41 Stephen:
I where there's this kind of fluid ambiguity in the situation. Thank you. How about the second source of inaccuracy that is failing to explain the data mathematically? They write explaining the data means assigning high probability to events w that make the probability of x high. The penalty for failing to explain data is captured by the second term of F, which looks like this.
42:14 Daniel:
Higher terms of the actual value are matched with high values on the distribution. We control Q to keep this term low. So this is kind of like if it were a linear regression and all the data points were lined up

and the line just went right through them. Then bit would be doing really well on explaining the data and that would be given a low score here, whereas if that weren't the case, it'd be flipped dean. So when I was doing my work, I didn't have access or maybe I wasn't looking hard enough for the Kale divergence.
42:50 Dean:
So I can remember even on here and some of these live streams saying I have no idea what that even means. I have a better idea now. But one of the metaphors that I tried to use was in terms of avoiding overfitting or failing to be able to explain the data was so all those horizontal and vertical ines creating a mesh acting as a filter, how far apart do we set those? What gauge do we set our mesh for in terms of what we want to have stay above the mesh and what's passing through. Now, again, maybe that's not sophisticated enough for a lot of philosophers, but to get the basic point down, that's the kind of example I had to provide to be able to give people some sense.
43:36 Not just that these lines are now rigid and the 20 is on this percent and the 40 is on this percent and never shall the two parse again. But the ines actually move. Thanks a lot. So you're so right about that. The example with the active coherent and the variational affordance is like discrete by discreet it's four quadrants.
44:01 Daniel:
So in some ways that's like the simplest model, right? It could be two continuum variables. It could be like the volume and then the cat's position on the x axis in a room. Now imagine if it was the x and the Y is continuous or something like that. But just even two continuum variables.
44:17 And you're totally pointing out where it's like you're going to put the points around, whether you put them right in the middle of the four quadrants or whether it's more scatter shot or something in between. And then there's two parameters. There's like a linear regression through the points and then there's how fine the mesh is and you're observing like pixel densities and doing a regression through the pixel densities. And so you could have a super continuous situation. It is a continuous variable inside the bedroom.
44:47 But then in the model, we just looked at it's in one quadrant and we talked about that when we talked about serval's paper and how it was just the park and the cafe and yes, there area locations within the park, but they weren't within our model. So we didn't deny the reality of that physically. We just were modeling statistically something specific. Okay. Steven.
45:11 Stephen:
The filtering could also be related to the sort of temporal sampling rate because if you're measuring every millisecond, if it's meowing or not, it becomes pointless. There's kind of a making sense rate at which the entropy is being converged at. And as we know in the brain, we seem to have multiple levels of that. Okay, awesome. Next two ones we're gain to go through just kind of quickly and specifically.
45:41 Daniel:
So let's put those two terms together. This is the overfitting and the failing to explain the data variational.

Free Energy f, the non metaphysical version is the sum of the penalties for overpitting and failing to explain the data. It's those two terms that we just described added together so that the best exploration, in a sense is the lowest on both of them. It's not over bit.
46:11 It fits it well and it doesn't do it any more than that. So simple as possible. Bit no simpler. Any

other number of quotes that's kind of this question. It's not the only way it could be written, it's not the only thing that fulfills that process, but it's something that can be used and it's very tractable.
46:30 As it turns out, this free energy has tractable computation. 13, page 14. So now it's possible to actually use that tractable approximation and do decision making. And here is where they have the decision making. Here, agreement means choose the distribution q that makes the following term as small as possible.
47:04 So this is where F goes from kind of being like a set of pipes with nothing really running through it to a specific finite set of tested alternatives. Those are affordance. In the case of action selection, they're discreet. In the case of a discrete inference, like is it in the bedroom or is it in the kitchen? It's continuum.
47:28 In the case of a continuous inference problem, like how bright is it outside on a continuous scale? But even for continuum things, sometimes we just do one through ten or one through 100 or one thought 124. So discreet state spaces are really important even if there is a continuity to the world. So those are the kinds of computations that variational inference helps perform. It takes something that's descriptive and moves it into a decisionmaking imperative.
47:55 Just like the L two norm or least squares is like a decision making imperative for linear regression. This is like an imperative for model fitting. In this framework, the free energy principle, the form here inference is the same as that of Bayesian principle discussed earlier. In both cases, you perform a calculation and set Q of W equal to the resulting value. The difference is that Bayesian principle concepts a direct calculation via Bayes theorem.
48:28 In contrast, free energy principle concepts what might be called an indirect correlation. Happily, in practice this can be done by trial and improvement rather than trial and errors. So that's axleconstant bacteria, the Bayesian and the variational bacterium combined with going to the bottom of the bowl on the smooth gradient descent landscape with a straight arrow utility and the solenoidal epistemic component, various algorithms for finding Q, the distribution we control are available depending on the details of the generative model classic citation that gets referred to a lot. One of the developments that prefigured active inference, the implementation of such an algorithm in a neural network. First, in 2005 old citation classic.
49:19 We're seeing that again in Model stream five in Alex Chance's work and of many others, that this format, even long before active inference, brought it onto the scene in our little side stage, using neural networks to fit variational Bayesian methods was a common technique in machine learning. Steven so when we say trial and improvement rather than trial and errors, it's basically saying that the error can be used and utilized in an ongoing way. It's not like you have to start from scratch and come up with another attempt from scratch. You're using the same basic architecture and just keep running. It's so true.
50:05 I never really thought how demoralizing Attial and error was like, how should we get stronger? Oh, well, you're going to try and then you're going to fail, when error is perceived as a failure knifely. But trial improvement would be like, we're going to try and we're going to improve. So yes, of course, error is implicit in that. Dean yeah.
50:24 Dean:
And I'm glad to use the bowl analogy because one of the things that I read and I was actually the one Zhat highlighted Attial and improvement thing because. For example. If you had a bowl field with

water and a ping pong ball floating on top and you had to drill a hole because you wanted the ping pong ball to settle at the bottom of the bowl at a certain time. You could continuously improve by adding more holes of a certain diameter until you were able to get that flow rate and have that ping pong Bull ball active at the bottom of that bowl at the particular time. At the discrete time that you were looking for.
51:00 That's not an error thing. That's just cell continue to get a little bit closer and closer. Cell figure out zhat. The dosage is, and I agree with you, a lot of people think that the basic research part of it is, oh, I failed. No, a lot of this stuff is I tested and then I tested again and then I bo, I came really, really close.
51:21 So now the difference is really low, which is what these authors are talking. All right, I'm just going to continue on because we do have a ton more to do. So that's still on the perception side. We're not talking about where we're going to go walking. We're talking about the sound of the cat and where the cat is located in the inference.
51:37 Daniel:
And so we're still within this empirical variational coherence area. This is the bowl. This is fitting. That distinctions, the conjoint distribution, that's the free energy distinctions. And that is the one that's bold like.
51:55 So here is the variational free energy of the black line. And it's basically the composition of two factors, penalty for overfitting and the penalty for failing to explain the data. And each of those have a certain distribution underneath them in this setting. So their combination is like F plus G of X. It's like h of x.
52:19 It's just adding functions together. So it's just another cost fitting function for the really specific kinds of models that we're talking about here. Let's bring in action. So now it's still the same case of W and X going to the agent. Now, notice that the agent wasn't drawn in the previous model.
52:38 It was just w to x. So that was probably a graphical as well as somewhat of a conceptual simplification. Like, I mean, these measurements, it shouldn't matter who's observing them, right? Oh, wait, quantum it does. But now the agent can also take action Z.
52:56 So Z is going to be the whole question of control theory and cybernetics and action. The previous section dealt with inference rule, how to choose Q of world beliefs on world states. This section is about acting. Now, suppose you can perform an action Z that will place the cat in one of two rooms. By changing the hidden states W, you can indirectly change future values of X or at least change their proportions or their likelihood.
53:23 So decision rules stem from measures of preference, because if you don't know where you're going, you're lost. Or if you don't care about the two things, then it doesn't really matter. One of the confusing aspects of active inference is that it treats the statistical model P, the one that is the actual distinctions we're trying to get close to. And this is like the key point that we'll be returning to you for a whole life, that model P is a measure of both probabilities and preferences. At the same time.
53:53 And that's going to be what we continue to talk about because it's one of the most important points that this paper makes clear in a way that other papers haven't really perhaps harped on in exactly the same way. Let's look at figure three again. Look at the yellow part. Active inference employs a controversial dual interpretation of P of W, probability of real state and probability of observation as probability distributions and preference distributions over hidden states and sensory states specifically.

Dean with the red text again, I.
54:33 Dean:
Don'T want to take up a bunch of time to this. We're having one of the authors or a few of the authors on we can probably pull this out a little bit, but for now, when we introduce preferences and probabilities, it isn't just a second consideration. It can almost run away from us really quickly if we're not really careful in terms of pulling back on the reins a little bit and really thinking about what does that imply. So I'll just leave that force now. Great point.
55:05 Daniel:
Thanks for sharing it. Succinctly they write recall that free energy principle inference councils choosing beliefs by minimizing a function that measures the cost of inaccuracy. And that's because the free energy calculation includes both of those features, the overfitting penalty and the failure to explain penalty. Action selection is governed in the same way as inference. Remember, we were talking only about inference when we were talking about the variational methods.
55:37 Now there's gain to be a twist, a slightly different cost function called the expected free energy. So that's why we were previously just talking about the variational free energy energy. Now we're going to be talking about G, expected free energy label G. The definition of G is closely related to that of F. The interpretation of the two penalty terms changes as the formalism is updated to reflect the fact we are now making measurements over expected future states.
56:09 So this is not just measurement errors. There is the fundamental unknowingness of the future. Since culture states have yet to be observed, the agent must average over them to obtain expected values. The penalties are associated with failing to satisfy preference and failing to minimize future surprise overfitting preferences. Failure to explain surprise expectation preferences.
56:38 Preferences. When? Now or then. Let's look at how those play out in this sort of action selection through variational free energy through time, aka the expected free energy formulation and how those two pieces

satisfying preference failure and failure to minimize future surprise. Look now, but this is sort of the elaboration or the cousin of this one.
57:05 This is like snapshot inference and now we're going to be looking at expectations through time.
57:14 Okay, so first feeling to satisfy preferences. So again, keep that simpler version in mind. This is going to be a slightly different one in six. They even write compare equation two.
57:29 I hope feeling to satisfy preferences given a clear enough term but it totally brings in something different which is something about the agent as Dean wrote so there's big implications of course because there can't be a nonpreferencedriven action selection in any useful sense whereas the variational one was just like given the scatter I want the best mesh and regression that one it does embody implicit assumptions about the world and so on but this takes it to a whole order level. And here's where that controversial dual interpretation comes into play. Not only is bit unusual to treat P as a preference distribution, it is unusual to treat the goal of decision making to produce a distinctions that matches that distribution rather than maximizing expected utility. So you don't need a reference distribution other than more for reward learning. Whereas here we're trying to realize our preferences and reference distinctions rather than maximize we're minimizing the emergence from these realistic but optimistic expectations.
58:37 So perhaps it is best to keep in mind that preference in this sense might mean something different

than utility in the traditional sense.
58:46 Stephen:
Stephen yeah, without going back into that but the whole point of having this reference distribution rather than expected utility which effectively again becomes kind of like equilibrium states, places where things settle and can be measured and a kind of stable you're in this kind of realm of a more fluid flux type process. So I think that's one thing and I think the other one is this focus on the future. The focus on predicting and things going into the future and how to make sense of that rather than looking back and trying to which is often what science is doing and explain retrospectively in the same way psychology is often trying to explain what it sees before it and coaching psychology is trying to see what can be done to get closer to something that's more suited. Great point. Thank you.
59:48 Daniel:
It really embodies the forward lookingness rather than the optimal reward or prediction on previous observation. Alright, so failure to minimize future surprise, this is the other term failure to satisfy preferences now failure to minimize future surprise formulas seven one of the tenets of active inference is that agents should act. This is an enormous stance to ensure that future data area not too surprising and so here is the formalism as written this is the failure to minimize surprise in addition to Conditionalizing on Z, z is action. So we know that the vertical line is conditioning on and then Z are the affordances like the action states in this simple example we're not going to go into the Markov, to the policy into the action state yet this is from the simpler cybernetic or sort of agent environment framing that doesn't distinguish that as clearly but Z is just an action that the agent engages in. The failure to minimize future surprise is conditioned on Z.
1:00:59 So it's not that there's some sort of world that we're not altering and then we're doing some strategy in that in alterable world, leading to this total ad hoc way of integrating the outcomes of action into the niche. The world states in the future have expectations that must be calculated as expecting on policy selection. So it's not just that some policies have effect and some don't. It's that the inference of the future failure to minimize surprise is conditioned statistically in the algorithm on the choices now, and that includes choices about beliefs. Doesn't it get so interesting?
1:01:40 So that is one of the cool parts about this calculation and then this expected free energy. Okay, stephen guess. Go ahead. That also brings in an element of this contextuality. It's what sort of choices were made then in context x.
1:02:03 Stephen:
Well, let's not use that context, right? It's important and it changes things. And you can't do Zhat if you're taking averages and sort of prebuilt models. Okay, so now just like we kind of looked at the two parse separately and then summated into F the variational free energy and then looked at those two parts. Here we've gotten to equation eight in the paper, which is G, which is a function of those two distributions, p and Q, as well as action.
1:02:37 Daniel:
And here are those two pieces that we just discussed. And then they write the third input to G is Z rather than X. So not observations but action. As mentioned above. This is because we are calculating the expected value over possible future sensory states rather than inferring on the basis of a sensory state that has just occurred.
1:03:01 Okay, so that's exactly what Steven said. F is really good for sensory inference. It's about

giving the just observed sensory data what the estimate of the world should snap to. But action is totally different, not just because it entails preferences like Dean raised, but also because the consequences of action in the future are unknown. So the distribution for planning as inference, for action as inference rather than for perception as inference needs to require Conditionalizing on action, not on sense.
1:03:37 Even though sense does come into play. It's a little bit like hidden away here s, Zhat, Zhat we're getting at, which is the sensory distribution noticeably not here but on the right side only. And then the function that we're minimizing on is action inference, active inference. And as with F, the measure G suggests the principle free energy principle in terms of action, not as inference, is minimizing the free energy on action selection that can be read as an approximation of not optimal Bayesian sensing but optimal Bayesian design of experiments and optimal Bayesian decision theory. Dean and I think right here is I'm just pausing for 1 second, I think Zhat, we're going to get into some more evidence of this.
1:04:30 Dean:
But I think this is the first moment when we can say active inference and free energy. Well, not free energy. Active inference does not necessarily constrain itself to being just a framework. It's actually a filter as well because of the active part. It's not stable.
1:04:49 It's constantly being updated because of that active piece and the preference piece. So we could call it a framework, but I don't think we're doing it justice. There's a framework aspect to it and there's a filtering piece to it. And so that's why I talk about search fields all the time. So I just want to drop that seed now so that when the authors come on, we can talk about that a little bit more in terms of the context that Steven mentioned about guiding.
1:05:15 Daniel:
Awesome. Thank you. So now we're going to return to the active inference. So let us present a solution to the cat example. For the problem to have a determinate solution, we need the conditional distribution world states condition on action Z.
1:05:31 That means that the consequences of action have to be estimated. If we put the cat in the kitchen, it usually stays there. So this is again the two pieces that action introduces into the puzzle is the question of preference, otherwise why bother? And the question of the consequences of action. So the red is a statement that's empirically observed from observed data about what happens when you are estimating location conditioned on action.
1:05:59 This is that Q of W conditioned on Z. And so you can see when it goes into the kitchen, it stays in the kitchen nine out of ten times. Whereas if it puts in the bedroom after some period of time like Stephen brought up, not one millisecond later, but 1 hour later, 1 minute later, it's model specific, it's time scale friendly, it's not time scale free. And then you can compute numbers having to do with action. Selection within this model bit is worth restating how unusual it is to interpret P as a measure of both probabilities and preferences.
1:06:37 But I mean, it's the letter P. There's nothing wrong with treating a distribution as a measure of preferences. Distributions don't demand to be interpreted as probabilities, after all. But what is unorthodox in what church and in need of justification is giving the very same mathematical term, two different interpretations within the same equation, so that's the two eyes at once kind of looking back and then theory go into a little bit more detail about what that actually means. We are not aware of proponents of active inference taking this interpretation line, but it appears to be a viable option.

1:07:11 So just awesome and clear writing and drawing something out through the re understanding and communication which happens synchronously and asynchronously. One of the ways proponents of the framework turn to this unusual interpretation to their advantage is by casting action as a form of inference. So here is from a Buckley citation and that's why it's called active inference. We just kind of talked about it a little earlier. So the mechanism underlying minimizing expected free energy is formally symmetric to perceptual inference.
1:07:46 Formally symmetric overfitting, failing to satisfy preferences, failure to explain the data, failure to minimize expected surprise on future data. That's why it's the only one that has the X in there. Rather than inferring the cost of sensory data, an organism must infer action that best make sensory data accord with an internal representation of the environment. Statistical

representation, not the debate on whether organisms internal representation. Two four simple model of selection.
1:08:14 This is where the Markov blanket is going to enter. In our model, X and Z are the inputs and outputs of the agents X observations. The Z actions, the set X and Z is the agent's Markov blanket. The term is derived from Jeffrey's work on inference using Bayesian networks. Pearl 19 eight classic citation.
1:08:33 Other live streams we talk more about Markov blanket. So we're not going to go into it too much more here, but it's definitely the tip of an iceberg if you want to check out more. But here in the sense required here, a Markov blanket can be understood as a set of nodes that screen off the agent from nodes considered external to it screen off the agent or screen off the internal states of the statistical model. Another toy model will help illustrate. Consider an agent phase service temperature.
1:09:03 X can safely lie between four and four units, temperatures continuous. Okay, but it's a discreet model. And so here death is coming into the picture on either end, too hot and too cold. So this is going to be like variational caterers. But now it's a freezing and a burning end of the room and the cat or the robot cat is going to be making decisions about what to do.
1:09:27 So the external world state is w the temperature and then the perception is going to be X, the observation. Notice that the value of W does not affect the agent's preferences. So the preference for living or for homeostasis or whatever, regardless of the observation in that snapshot moment, but not precluded over longer time skills, all the agent directly cares about is its surface temperature, denoted by X. That's why the two rows are identical. So these are sort of the observations and the different actions that can be taken to move between one end and the other.
1:10:07 Perceiving only the temperature, the agent tries to guess how to act, how to stay within its expected range. And then this is sort of the intuitive pseudo code. When the temperature is high, you want to go towards the lower end. When the temperature is low, you want to act to go towards the higher end. And so here is like the simple example.
1:10:32 This is kind of like the bacteria zhat has the right priors versus the one that's just deciding randomly or without any resemblance of relationship to the other observation. And so here is the smart agent that's just keeping its free energy every time it gets up. As it moves away, it acts to bring it back down into alignment and then the agent's control over its external state is 95% accurate. So 5% of the time it slips and then that's what they say it's grasp slips. The optimal control, the handle has been lost because of a motor in effectuality, but that can be recovered, whereas the randomly acting or just sort of like the sort of Brownian walk diffusion process ends up dying.

1:11:25 Dean:
Okay, Dean, all I need to say here is did a great explanation and if this was your first encounter with the W and the Z and the X, you'd have to really, really slow this down because the first time you encounter it, it takes more than one position. You might have to go over it a third and a fifth and a 7th time for it to actually make sense because we all have a certain capacity in terms of the amount of variables we can juggle at once. And when I first looked at this bit made sense to me. But I could sense from somebody who's maybe coming from a philosophical background and not necessarily having the same degree of statistical hands on experience as maybe the three of us do, this would be a moment where you really want somebody to hold your hand.
1:12:22 Daniel:
That's what community and active lab is for because then it can be like an interaction and every question is welcome. So as long as there's attention in the game, everybody is going to make it. Stephen.
1:12:38 Stephen:
So this also does give an indication that with variational free energy, having some sort of perturbations can be useful, particularly if you have multiple parallel sources of information being integrated. So having some noise is a good thing. It actually gives you a way to start to make inferences. One question is there on the left there's no real learning happening bit. It still makes it even without the learning component still is more stable.
1:13:15 Daniel:
Yes. It's not doing parameter updating. It's just like a previously learned association between the temperature and the direction to move and also noise. The observation of sensory is assumed to be perfect here. So there's many layers which can be brought in.
1:13:33 But this is kind of like the kernel motif. Okay? The correspondence between high values of f and lifethreatening states lead to a third form of the free energy principle. So we had inference and action perceptual inference, then we had action selection. And here is free energy principle selection.
1:13:55 Any system that survives long enough will act so as to appear to be minimizing f. That's the first time we got any discussion of far from equilibrium thermodynamics of antidisciplinary systems, resilient systems, anticipatory systems, except indirectly through action. But this is the sort of selective Darwinian side of FEP. Okay. Of course there's a ton that could be said here.
1:14:27 This is not a normative principle, not a suggestion to agents regarding how they should perform inference, but a means of describing how agents behave. Axle Paper minimizing free energy is not living alone, but living systems will be those that appear as if they've minimized free energy. And then here I think someone wrote Zhat. I just wrote that in there because that's going to tell you what your autobiography is going to sound like given that you're still alive and can write one. Yes, my last words are in recent work first and gives a deflationary interpretation on which agents do not in fact minimize anything but perform acts which can be interpreted as minimizing f.
1:15:09 So c live stream numbers 34 0123 that is the reason for the emphasized phrase so as to appear to be minimizing f that's deflationary instrumentalism highlight. Despite this deflationary approach, there is a link between this and the earlier principle agent subject to the free energy principle of inference. Perceptual inference ought to minimize f. So if this is odd, is tied to their survival, then the normative principle has the same underlying justification as the descriptive principle. So this is sort of I

don't know if it's been noted before, but basically it's equivalent to saying the evolutionary OT is and is.
1:15:52 So it's kind of like not from the fitness side, the Malthusian Darwinian side, but from the anti dissipative side. This is how things have looked. It's like saying fitness isn't necessarily being projected into the future, but if you do, the computational fitness can be assigned to like different single nucleotide polymorphisms that have had different success and you will only see successful ones. But it's a bit more complex than that in the moment. So here are the three piece, the tail of three piece.
1:16:27 We had the tail of two densities. What other jokes have we had? In each of the three examples discussed in a section, there has been a distinct role for the distribution P and a distinctions interpretation of each model narrow sense. In our first model, P was a generative model employed by an agent. It was therefore interpreted as representing probabilities, like where the cat is.
1:16:50 But now in order to introduce action in a meaningful way, we had to have preference, like I want the cat to be in the kitchen. So when we brought action into the game, we had to introduce preference. What makes active inference similar but also different from other framework? Probabilities and preferences are represented by P. In addition to representing probabilities.
1:17:12 In the second model, p measured the stability of certain future states over others. I expect you to go to school every day. That's something having to do with action if it's serious. It was therefore interpreted as representing preferences. In our third model, P, talied the historical frequencies of a set of hypothetical ancestors fitness.
1:17:33 It was therefore interpreted as representing the fitness of different states. So supporters of the framework often point to the third role, fitness PH, to explain how P can simultaneously fulfill the first two. It's like if that thermal bacteria is rocking its niche, it will have high fitness. Okay, so that is where the three P's get us. Here's just a brief look forward.
1:18:06 So for any of these next slides, we're not going to go into the actual very nicely fleshed out arguments themselves, but Stephen or Dean, just raise your hand if either of you have anything to add on, like each of these section headers. So section 2.5 is extensions to the model, more things to learn, more ways to act. We've seen adjectives added to active inference and deep sophisticated contrastive reflective zhat, other adjectives have we seen that's sort of this section of the guidebook. It's like there's your USB port. What can you have added into it or how can it be developed?
1:18:46 And so that's where we see sort of the adjectival family of something, active inference, maybe even N active inference coming more into the philosophy side. But also there's all the elaborations that we've seen of the actual parametric model in the narrow sense. Sometimes it's in both camps, like affective inference, has to do with a model derivation or metacognition, as well as something about the model in a bigger sense. But we can recognize both those lanes at once. Stephen yeah, I mean, one of the ones in active inference, reciprocal active inference, there's a couple more that's

definitely true.
1:19:32 Stephen:
Just one thing I was going to throw in. I noticed they talked about this, and I know it's in the quote, but they talk about any system. I always wonder whether that's a little bit of a piece of paving stone waiting to be tripped over. Because I kind of feel like if you're going to say it may be any nonlinear dynamics system or nested systems of systems or things, I just always think that can be a little bit of a hazard. Yeah, it inherits a lot of the legacy ambiguity around system like you've brought up a bunch of times.
1:20:09 Daniel:

So it's really helpful. So in section three, notice how the history, brief history of the free energy principle comes after what we just spent the last hours and pages on. So it isn't a history of science perspective, but it is being recognized as important. And so the free energy principle is a modern incarnation of idea that have been raised sporadically over at least the five decades. It combines traditions from physics, biology, neuroscience and machine learning in other areas, especially the modifications and increasingly the applications.
1:20:46 And it's a bidirectional freeway. It's not just two lanes in both distinctions, it's going both ways. So this is sort of the history, which is fun because it's a recent history in some parts. Okay, section four moves from the historical to the philosophical. So section four, dialectic, the free energy principle and related claims, mathematical, empirical and general claims.
1:21:12 Section four one, this is where all that mathematics groundwork pays off, because in the author's words, we think a great deal of confusion can be overcome by considering three kinds of claims. First, there are mathematical claims. Those were the ones that were just brought up in earlier sections. So that's the theorem, the scientific model and the statistical techniques in the more narrow sense, and by doing good scholarship, we show that the core features absolutely predate active inference there's less controversial than some might suspect. However, Friston colleagues have since introduced many novel mathematical elements, like the perception and action interpretation on the Markov blanket.
1:21:59 Importantly, claims in this category do not need to be interpreted as statements about real systems in order to be evaluated. So part one is its instrumentalism. Part two is separate the parts that predate active inference from some of these more recent derivations, even within the only technical area. Second area of confusion, or the second way that confusion can be overcome by considering another kind of claim is partitioning off. We can add like a line here from that mathematical everything that was in the section that we just discussed, plus stuff that was more recent, like 32.
1:22:34 There are empirical claims about cognitive and biological systems, how brain and bodies actually work. These are the remit of cognitive neuroscience and biology. So those are empirical biological claims. Third are general claims that typically abstract across a wide range or by class of empirical claims. So that's like the sort of everything nested systems, collective behavior angle.
1:22:57 So separating those and maybe there's more is really helpful because sometimes people say, well, this general claim is true because look at how this in the skin works. Well, what about the skin? Well, look at how the math works. And why does the math work that way? Because of the general claim.
1:23:12 Is that an argument? What is the justification and the links among these dialectical categories? Well, if there area three kinds of claims, mathematical, empirical in general, then there are all the edges of that triangle. If you had a fourth one, you'd have all the edges of a tetrahedron, and then you'd almost have a model. The mathematical to empirical direction invites philosophical analysis due to novel interpretation of scientific model terms.
1:23:41 So how can math be used to justify empirical claims? Why does equations have anything to do with what people say about the brain and the body and the niche? Why is that justified at all other than just other people in their epidemic authority have done it or it's how it has been done? Stephen instrumentalism also gives a kind of a bridge between realist science and applied science, and it's kind of sticking somewhere between the two. So I think that's quite a useful piece of this adds to the

equation.
1:24:19 Nice and then the last two edges of that triangle are how can mathematical not both directions on each edge, but how can mathematical claims justify general claims? Cell how could you say that about nested systems, about nested Marko blankets? The math. Okay, that's important to investigate. And how can general claims justify empirical claims?
1:24:46 How could you say that about the ants? Well, fitness or dissipative system. So how can general system claims justify anything about empiric? So those are some of the edges of these three kinds of claims. And there's also claims and subclaims, which is why it's really important to have rhetorical system mapping and an ontology for active inference so that we can actually learn and apply across languages and through time.
1:25:14 Stephen:
Stephen yeah, and I think also we can think of this as structural and functional insights being gained, rather than necessarily repeatable measured outcomes every time being gained. So there's an idea that these insights might reveal something about the structure or the functionality of the dynamics, knowing that no one implication may ever be repeated quite the same way, particularly if it's got fair few variables. Yes. So, the concluding remarks the active info framework is incredibly ambitious. Is it the framework or the people in its explanatory scope?
1:25:56 Daniel:
From humble beginnings as a theory of brain function, it is now position as a framework for understanding life itself. There is a critical tradition in the philosophy of biology inspired by Richard Levels with regard to such ambitions. Many then will approach active inference with skepticism. Healthy skepticism is a good thing, but healthy skepticism is informed skepticism. Unfortunately, getting one's head around the details of active inference is no small task.
1:26:27 Our goal in this introduction has been to clarify the basic mathematics story and internal dialectic of active inference, in that order. Those were the sections and draw attention to some key concerns. With these details on the table, philosophy of biology are in a better position to critically evaluate the framework. We look forward with interest to seeing the results. Classic future looking last sentence.
1:26:55 So that's the final lines. We have a ton of things to discuss in 37.1 and two. It would be awesome to have any of the authors as well as any other people who just want to jump on for a returning or a first time discussion. But we'll close under the buzzer in the third period. I know that's how they count up there.
1:27:17 Dean so, any final comments on just what you're looking forward to discussing? Dean first, because you never get the last word and then stephen yeah, I. Don'T want the last word. So one of the things I want to talk about in that point one is the general claims, because I get to trot out one of my favorite parables that I made up, which is three functions walk into a bar and I want to be able to because I get lots of mileage out of that. And whether it's three functions or it's probability preference and fit, the same holds true.
1:27:51 Dean:
It can be a great taste and less filling. So I want to have a look at that because I think that really tags on to the idea that what they're talking about here in terms of a guide zhat also set us up really well for creativity. And then I also want to be able to say that that creativity isn't because we're framed in, but

because we. Can filter as well interpretation of a function walking to a bar. Steven yeah, I'm really curious about how especially we speak to the authors.
1:28:23 Stephen:
The first principles of hidden states and inferences and which ones are selected and which data is available to actually make inferences on can be used, particularly, for me, the example of psychology versus coaching psychology and that type of paradigm shift. Awesome. Yeah. I really appreciated both of your perspectives on this paper. It really shows how different life experiences can be in conversation with some of the technical details.
1:28:57 Daniel:
So thank you both, and for everybody who's watching and participating, see you around the lab. See you in the encoding weeks. For one dot, two. Peace. Bye.

Session 037.1, February 2, 2022

https://www.youtube.com/watch?v=GHcpJ_bMuu4

A first participatory discussion on the 2021 paper "*Free Energy: A User's Guide*" by Stephen Francis Mann, Ross Pain, and Michael Kirchoff.

SESSION SPEAKERS

Daniel Ari Friedman, Stephan Sillett, Dean Tickles, Bleu Knight.

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1:53:39 Any last thoughts?

TRANSCRIPT

00:23 DANIEL FRIEDMAN:
All right. Hello and welcome to ActInf Lab Livestream Number 37 Dot One: “Free Energy, A User's Guide.”
00:31 It's February 2, 2022 22, 20 days till the Big One course. Welcome to active inference lab. We area participatory online lab that is communicating, learning, and practicing applied active inference. You can find us at links here on this slide. This is recorded in an archived livestream, so please provide us with feedback so we can improve our work.
00:58 All backgrounds and perspectives are welcome and we'll be following good video etiquette for live stream. Maybe people can raise their hand visually so there's not a little Jitsy blip until we figure it out. Or either way go active Inference.org. If you want to learn more about participating or check the Koda link here. Okay, today in 37.1, the goal is to learn and discuss and also appreciate having Stephen Mann, the first author, here with us.
01:30 This paper. Free Energy a User's guide. And for this 37.1, we'll start with an introduction and then we'll just fire up some slides and hear perhaps an opening and a contextualizing statement from Stephen to be introduced last and then go into whatever questions that everyone else has brought and anyone teaching live. So I'm Daniel. I'm a researcher in California, and I will pass it to Stephen.
02:02 STEPHEN SILLETT:
Hello! Steven. I'm a practice based PhD researcher based in Toronto, and I'll pass it over to Dean.
02:17 DEAN TICKLES:
Morning, everybody. I'm Dean. I'm out here in Calgary.
02:18 Dean:
I'm somebody who did some programming, went from being an educator to a wayfinder, and I find guides really an interesting topic to have conversation around. I'll pass it down to Bleu.
02:31 BLEU KNIGHT:
Hi. I'm Bleu. I'm a research consultant in banks out of New Mexico, and I will pass it to the first author, Stephen.
02:44 STEPHEN MANN:
Hi, everyone, I'm Stephen. I am a philosophy PhD, currently a postdoc in the linguistics department of the University of Surrey and a guest at the Max Plant Institute for Evolutionary Anthropology in Leipzig, where I live.
03:02 Daniel:
All right, maybe Steven S. or Steven M. Would you like to just give a little context on the paper? Like how did this fit into your PhD or research interests? How did this specific collaboration come to be in the format of the paper and the way it is? Sure.
03:23 Stephen M.:
Well first, thanks for having me and thanks very much for last week's session with Zero. I think you did a really excellent job at Overviewing, and I'm really looking forward to talking about it today. This paper came about because we, myself and Ross and Michael, the other authors, had been in discussions with a few other authors around a symposium discussing active inference and the free energy principle and also predictive processing at the Australian Society for Philosophy and Psychology Conference. In

2018, we put together a small symposium. It went relatively well, and after a few more months of sort of pursuing ideas back and forth, we approached Michael Weisberg, the editor of biology and philosophy about putting together topical collection, sort of like a special issue bit, sort of collected digitally.
04:20 And eventually after sort of pitching it to him and managed him to get to talk to him in person. He said that he and the other editors were quite excited. But what they wanted was an introduction from us that would explain the mathematics and the philosophy dialectics behind sort of at the core of active inference and the free energy principle in a way that was accessible for philosophy. And so we said sure, we can do that. And that was a little while ago we started soliciting out for papers.
04:58 We've now published most of the papers in that topical collection. And since then at the same active states finalizing, finishing off my PH. D. And then moving to Europe from Australia where my PhD was, we were getting to grips with the real mathematical core of active inference and trying to figure out what was the necessary mathematics to explain the basics of the framework and then how to present that mathematics to a philosophical audience who has some mathematical competence. And the result is the current preprint.
05:34 So we think we're probably about one more set of provisions away from submitting for publication and it will eventually come out as the introduction to that topical collection. So what I'm really interested in hearing from everyone else today, the same thing we're interested from hearing from the wider community, which is the reason we released a preprint, which is just comments and questions and any kind of corrections that can help improve the paper so that it's final force sort of even better, as good as we can make it.
06:08 Daniel:
Okay. Thanks for the awesome context, Stephen S. Thank you. Yeah, we really encoding this paper and one thing I'd be interested to think about, even though you sort of aimed at maybe a philosophy audience is some of the aspects of it at this nascent kind of foundational level could help in applied context that may be beyond the modeling. So we're kind of interested in some of that.
06:36 Stephen S.:
So that might be something we might tip into even if it's not in the remit of this papers direct publication. I think it would be really helpful in the broader sort of journey of using active inference in the world.
06:53 Daniel:
Awesome. Okay, Bleu or Dean, would you like to start with a question? Or we can return to one of the points that were already kind of brought up.
07:07 Dean:
I'm good for now. Okay, so maybe just one starting point was just what backgrounds like how did you go from thinking about who you wanted to make the paper accessible to writing it a certain way? And then you mentioned it was for philosophy. So what is the impact in this community that you'd like to how would you like to update the generative models?
07:39 Stephen M.:
Nicely put. First and foremost, we would like to fix in their mind the relationship between variational inference and Bayesian inference. So I know that's something you've talked about before, it's something that predates the free energy principle and active inference as an explanatory framework for cognitive science and biology. And it's something which, as far as I can tell, is sort of the first step in understanding what's going on with that mathematics. So that's sort of the key thing we want philosophers to sort of have in their mind also, because almost all philosophy, especially philosophers of cognitive science, but also philosophers of biology, will be familiar with Bayesian inference, at least to some extent.
08:31 So by pointing out that what active inference is is something sort of a step to the right of Bayesian inference, something that they can start to understand by analogy with that, we hope it will

stop them from sort of getting scared of all the complicated mathematics that you can read in a lot of the papers. So that's on the math side, on the philosophy side, a lot of the stuff in section four of the paper was our attempt to really strip back a lot of the claims that were being made, but also sort of categorize the claims that were being made. One thing that I noticed in reading the literature and attempting to understand it was that different kinds of claims were being conflated and there was jumping around from claims in different domains, mathematical claims that suddenly leverage to justify an empirical claim and then suddenly move to an extremely general claim about all of cognition science or all of biology in general. So that's the second thing we want the philosophers to get, that it is possible to disentangle these claims despite the fact that they are habitually sort of conflated or not made distinct enough in the rest of the literature.
09:48 Daniel:
All right, one follow up, and then I see Stephen and Dean. You mentioned that Bayesian inference may be more familiar, especially because it's used in all ines of modern statistical descriptive approaches as well as generative. Just to hear it in your own words, where do you think variational inference is more familiar? So who does it represent? Who's more familiar with variational methods or who would be familiar?
10:13 And then what are the key differences?
10:17 Stephen M.:
Sure. So my understanding is that physicists, statisticians and machine learning practitioners may well have come across variational inference, certainly will have had a much better chance of having come across variational inference than philosophy, at least as of 2022. What I understand variational inference to B is a certain kind of technique for choosing a probability distribution over unobserved states. That started in physics. As I understand it with Feynman.
10:56 Although I put a little footnote in the preprint pointing out that I haven't been able to translate the stuff in that Feynman book to the later stuff. Especially stuff that David McKay talks about in his textbook on information theory. Which includes some issues in variational inference. But as I understand it. Started in physics.
11:17 Then was adopted into sort of statistics more broadly as a means of approximating Bayesian inference in cases where exact Bayesian inference is too difficult to carry out. Too computationally difficult. And then move from statistics into teaching learning. Where it's possible to actually build machine learning algorithms or systems that can perform variational inference. And then from there, it ends up being in the active inference framework.
11:45 Daniel:
All right, thank you. So, Dean, first. Stephen, thanks for joining us. I really appreciate it. Here's a question for you.
11:55 Dean:
Now that an examination of the situation, and the situation, as you stated, was kind of math and philosophy, and now
I've got a relationship, and we're going to outpops a guidebook or a primer when the pump is primed. What do you see as being the affect of that relationship between the sort of philosophical audience and the math that was used to get us to this place?
12:34 Stephen M.:
Relationship between the philosophical audience and the math that was used to get us to this place? I mean, first and foremost, I want the philosophical audience to gain a certain kind of facility with the maths. I think one of you I'm not sure who of you it was, but in the .0 put it extremely well by saying it's like learning how the horse moves in chess. I think it might have been Daniel, but I don't want to attributes it to you. Giving the philosophical audience the basic understanding of the most basic maths will give them that first kind of tool which they can then go on, if they so wish, to build up and learn more of the moves, learn more of the complex maths if they want to, then go on and interrogate the rest

of Zhat literature, which is more complex.
13:21 We've tried to sort of forego too much critical analysis in the paper. There is some in there. We've tried to forgo that a little bit just in order to get the understanding of that maps across. Okay.
13:40 Daniel:
I can follow up there. Zhat, does it matter for the philosophy? So, Zhat, are they in your sense or their sense? What will knowing the difference between Bayesian and variational help them evaluate, or what will seeing it structured this way help them evaluate? I think there's a few.
14:04 So I hope other people also can think of philosophy questions that knowing the difference between the two would help you change your mind on. Yeah, I mean, the simple answer is just it will help them understand what Friston is claiming. And by Friston, of course, I'm using him as just an umbrella for anybody who's writing positively in the active inference tradition. Attention to demonstrate Zhat, the active inference framework can provide or inform certain process theories that explain cognitive or biological systems. A lot of us need to know the difference between Bayesian inference and variational inference because they need to know what it is that fitness claiming can be attributed to systems like this.
14:53 Okay, Bleu on that.
14:58 Bleu:
So I have a question and like, maybe I missed it and I was looking I just did like a quick control up on the paper just to make sure that I didn't miss it. And I'm not misinterpreting. But in your explanation of the generative model, I just wonder why you didn't choose to go into the recognition model. And I think that while you discussed at length like P's and Q's, why did you leave that out? Or do you think it's not significant or did I miss it and did you talk about bit?
15:35 Stephen M.:
So by the recognition model, I understand that to be a sort of alternative way of doing inference that an agent could employ. So I'm saying what I understand by it so you can correct me before I try and answer the question. I understand it to be. Yeah, an alternative to generative inference is just to employ a kind of recognition model which simply takes in data and immediately produces some kind of statistical result from that data. It doesn't need to simulate or generate its own data and then compare that to what it sees.
16:09 That would be the generative way. Instead, it just applies some kind of, say, mathematical statistical function to the data and then gets a kind of result which describes what it hasn't observed. Is that what you meant by a recognition model?
16:25 Bleu:
No, I'm referring to The Paper. The Tale of Two Densities. The 2019 Paper by Bramford Al. And in that paper, they refer to the recognition model as the cue. Right.
16:42 The inverse of the likelihood model is the mapping from the consequences to the hidden causes. And so you got really into the map and discuss the generative model, but just didn't acknowledge this recognition model. And I just was curious as to zhat. Okay, so you just mean the distribution queue by the recognition model?
17:16 Stephen M.:
I haven't read a tail of Q densities. I should say.
17:20 Daniel:
The recognition model is in the mind of namespace of expectation maximization modeling. The recognition model is like the sensory update and then the generative part was emphasized. I hope that's not too simplified or what two densities were. And then the outbound was more like associated with the generativity. And that's also that's why it's important to go from the frequencies to the Bayesian at all.
17:50 Because with Bayesian generative model, model like the model can be run both ways, though it's used with different adjectives that's like variational, auto, encoder. That's all these methods where it's not just descriptive modeling on a data set like principle component analysis or multiple regression. It

doesn't just describe then it can be used, although those can be used or be thought of as Bayesian like and be used in a generative way as well. But that's the part that people will have less empirical experience seeing. But let's think about this and then return to it next week.
18:29 Yeah. Okay. So Stephen S. Just following on from. The Bayesian, which is often used in the embodied context, people think about encoding and multisensory integration and that type of work and that field is a bit challenged by moving over to this variational machine learning paradigm because it's highly mathematical.
18:55 Stephen S.:
But what's interesting with active inference and bit sort of comes back into that being grounded in embodied action because that gives the preference somewhere to be anchored. So how do you see this going back into embodied cognition as a way for those preferences to be grounded?
19:26 Stephen M.:
That's a difficult one for me to answer, in part because I'm not really part of the transition that emphasizes embodied and inactive approaches to recognition model way I was taught it, they were sort of alternatives to the representationalist tradition and I was much more in the representationalist tradition. So there has been some talk of whether and how free energy approaches support one or the other of those two traditions. And to some extent because I'm already sympathetic to the representation of this tradition, I'm already leaning towards the idea that a free energy approach will support that as opposed to an embodied or an active kind of approach. Which is sort of a shame because like all of those kinds of binaries, it's probably somewhat a false dichotomy and it just means that my attention has been directed elsewhere than your attention in looking at these issues. And so yeah, I don't have enough of value to add, unfortunately.
20:45 Daniel:
Yes. Steven 1 second, but our previous paper, 36 was like a taxonomy of perspective on the representation question in FEP. So I think we're all very primed to just take Bit totally open state and is every possible stance for every person to focus on. It's just kind of not within our time and attention capacity. So I think it just speaks to like a diverse field where of course people are focusing on chemistry of this element, of that element.
21:23 It won't be exactly that split. But in the broadening field of like active inference and FEP there's going to be people who are focused more on one question or other. So that's kind of cool to like know where we have similar regime of attention or not. Steven yeah, I'm agreeing with Daniel and also, actually we found this really, really helpful from an embodied perspective because the way that you separated or you gave the probabilities and preferences working together. Bit.
21:56 Stephen S.:
Was kind of like a deflated or a more nascent form of representation and that ines quite nicely with potential ways that inactive approaches are also potentially there because of the nature of preferences. So you start to have a way where they can both live together because I don't know, we were talking about this the other day, weren't we? Daniel Zhat it wasn't so clear how these two can live together and often when people who area from philosophy. Quote the free energy principle. They talk about early papers like 2000, maybe ten years ago even, and that is often then a false argument that gets painted.
22:37 So now we've almost got a new paper which can kind of help ground those philosophers. I wonder, Zhat, your thought is in terms of whether you're trying to help people use the most latest form of free energy principle when they were talking about philosophy and to stop some of the correlation of just people criticizing models which are now out of date. If Zhat was part of your rationale for the way this paper was created.
23:08 Stephen M.:
Yeah, we absolutely wanted to direct people's attention to what we thought of as the real issues, in a way the appropriate issues. I mean, we reckon that a critical assessment that is not well informed by the actual workings of the theory is not going to be helpful because you might accidentally hit on a critique

that works, but only accidentally. If you're going to criticize a framework, you better at least understand what's going on. My worry is that it will become out of date as things change, but there's not a lot you can do about that. I mean, it took us quite a long time to get this first draft together, to get this preprint together and sort of hoping that things haven't changed so much that it's out of date by the time it comes out.
23:58 I mean, one way to post all that is to just be as basic as possible so that you're really capturing the core that can't possibly change, but otherwise your best chance is just to publish what you've got at a particular time and keep your eye on how things change and update as you go. Thanks. Yes, Dean. Steven, I use a lot of metaphors. So if you walked
into a singles bar and one of the singles was a philosopher and the order single was a mathematician, and you had to guess.
24:32 Dean:
Now going through the process of building that guy, right. Like you're not match.com, but you have to make a guess as to whether that long term relationship, they walk out hand in hand or they're completely repulsed by one another. I know it always depends, but you're talking about updating the guide. I kind of want to go back one previous step. What keeps them together, what pulls them apart.
25:02 Stephen M.:
Yeah. So how do you write what is essentially a philosophy paper but include mathematics in a way that does justice to both? Is roughly how I'm hearing that question. Well a longterm relationship, right? Like they still dot two, have some compatibility.
25:19 Right. And Philly's point was up to now it's been I don't know if I even want to go to the bar. So that's what I'm asking you now based on what you've journeyed into. Right. Because not everybody I appreciate the idea of the guidebook because not everybody goes into situations free.
25:41 Dean:
Right. Sometimes you get dropped into operating point, it's a little bit more intense. But what causes people to go freely into that kind of relationship and sustain it over a long enough period that it does make sense? Bit doesn't remain kind of a superficial thing or just a concept that it actually becomes realized. I was curious what your thoughts on that area?
26:11 Stephen M.:
I think that trying hard not to repeat myself too much. The way I try to think about that question is to try and think about what has prevented philosophy from really accessing the mathematical parts of active inference so far. And that's just from sort of communicating with philosophers and talking to them and hearing their dissatisfaction with it. And it was always just that there was too much of it too fast. And so the only approach we could see that could remedy that was to go as slow as possible in a way.
26:52 And so spend sort of have a much heavier ratio of words to equations in a way and go into much, much more depth in explaining each equation as it comes along rather than throwing all in at once and then decomposing it. One of the earlier versions of the draft, we started with the main equations and then decomposed them. In the current draft that you've read, we start with the components and then build up to the main equation. That was a little bit risky I thought, because I was worried that people would feel we were holding the main event back for too long. But so far it seems to be working.
27:38 I'll say I'd be interested to hear your thoughts on that approach, whether you think that meshes together well enough. Yeah, no, that's one of the things. And again, I don't think mathematicians are trying to be pushy, but if you don't have that context, bit can feel pushy. And so how long you're willing to leave something open before you drop the big questions is sometimes easier for somebody then to size the situation up and contextualize it. So in this delivery, I don't know previous versions, right, but in this delivery, in that respect, I actually think it makes it less intimidating.
28:19 Dean:
But that's my personal opinion. Sorry Steven, I know you wanted to say something. Steven? Steven

yeah. Just carrying on from what Dean was saying as well.
28:32 Stephen S.:
You looked at the inference model almost prior to having a Markov blanket and I thought that was quite useful. And one thing that maze me think as I was reading it, and I'd be interested in your thought is bit helps with this idea of really thinking about how area we going to create the blanket, when does the blanket come into play and what assumptions are theorem about the blanket. In some ways it's easy to pick up a pre built idea of what blankets are and then model off that was like, okay, cell, let's question that. And that actually could be useful at a more heuristic level for other fields of practice. So I'd be interested in your thoughts about what do you think your motivation for that and also maybe the sort of surprising or unsurprising outcomes of not going straight for the blanket.
29:26 Stephen M.:
Well, one of the big revelations for me in research in this paper was that you can talk about variational inference and you can talk about minimizing expected free energy without talking about Markov blanket. I had sort of come into this with just sort of a huge deluge of literature from the active inference tradition, lots and lots of key words or what could more uncharitably be called buzzwords like Markov blanket and nonequilium steady states and things like this. And it was a concern that I would first have to understand statistical physics and fluid dynamics before I could understand the claims that were being made about inference. But looking back into the history and you reality that first of all variational inference is a precursor to active inference so you can think about variational inference in its own little bubble as we have it in its own little selection and then the sort of next step which is novel and is quite excitingly novel which is minimizing expected free energy can also be construed just in terms of decision theory. As far as I can see, you don't have to think or talk about Markov blanket's at all to talk about vision theory as minimizing expected free energy.
30:48 So the reason why we separated them was because they're separable. The reason why we put those two first variational inference and expected minimizing expected free energy is because I think they are simpler and easy to grasp. Zhang we were trying to start from the simple and build up to the more complex. I think it's definitely true that the most intriguing and possibly the most difficult part of understanding this whole system which Friston is building is understanding the things to do with Markup blankets in real like physical situations. But what I'm sort of interested in now to give you a preview of what I'm like thinking about next.
31:30 The thing which I'm more optimistic about being able to make headway on is investigating minimizing expected free energy as a vision theory that sort of gets the middle group between it's not just something that prefigured active inference as variational inference did. It's not something that seems to require a very large amount of mathematical understanding as the Markov blanket stuff does seem to to me it's something which is claimed to be a certain way of approaching decision theory. Decision theory sort of a philosophy philosophical sort of technical term or a statistical term. So it's that nice middle ground between novel but understandable which is why the thing that I'm sort of most interested in investigating next is the expected free energy approach. And again, I don't think you need to talk about Markov blankets to talk about that.
32:25 Daniel:
Thanks for sharing that one thought on where the Markov blanket comes in. So you said Zhat variational inference and the minimization of expected free energy in the concept of a paper that was structurally laid out with first perception and then introducing action into the loop. So it kind of fits this perception of case as like active inference are not possible. And so that's the special case, the more general case is when action can come into play. That whole realm of action theory, decision theory, game theory, cybernetics, signal processing, none of that it was said requires the Markov blanket formalism.
33:18 I'd like to maybe add that there may be a weak sense requirement like in the sense that on a Bayesian graph or using Bayesian methods, using Perl 1988 version of the Markov blanket, there are

Markov blankets in the machinery of these Bayesian methods because there are variable that are isolated or conditioned on each other. So that's like the trivial Markov blanket. The non contentious one that people are not spending a lot of time and attention on that and then part of the unknown or at least less clear is the action and perception interpretation or affordance zhat Friston has introduced kind of taking the unitypal Markov blanket concept and splitting it into like an incoming sense state dependency and an outgoing action state. And then none of that gives a clear action perception topology which is why we've seen like around the clock and then switch the ones like action and sense are connected and backwards arrows. So there's the part about the partitioning of the Markov blanket and then taking something that's kind of a trivial consequence of statistical model and then tying it to potentially realism in the strong cases like people saying mark all blankets as defining things and then even just within the formalism.
34:54 How do you go from how do you ramp up the meaning of this Markov or does it need to even be that way? Which is mind of related to this question which I'll ask and then anyone can give a thought like you talked about necessary and sufficient. So is this some of the necessary and sufficient pieces of FEP Zhat? Is necessary like what's the kernel that everything else can continue to elaborate around? What section?
35:27 In page number please?
35:32 Stephen M.:
Well, you'll notice that we were cheeky in defining three distinct free energy principles, probably none of which would be assented to by the actual proponents of the free energy principle. Yeah, exactly. Could you go through and just describe in a few like sentences or just what is each one of these the three free energy principle inference, action selection. What did they mean to you? First one free energy principle for inference as we've defined it is when for dating your sorry my cat is biting.
36:08 Dean:
Me.
36:11 Stephen M.:
Holding up here cell. The short version is choose Q by minimizing F. So choose your beliefs about hidden states by. Minimizing variational free energy. So it's a principle in the sense that philosophers would call a normative principle.
36:33 It's a command for how to act. In this case, the specific kind of action, that is how to choose your beliefs, okay, and finish your principle for action, also a normative principle telling you how to act. And this one is again in our terminology, choose Z by minimizing G. So choose your action by minimizing its expected free energy.
37:07 And this is all for anybody who's teaching this, who hasn't looked at the paper. We've tried to sort of describe in very slow but understandable way what these exafferent sort of letters are standing for. And we give the definitions for discrete case.
37:27 Daniel:
Okay, so we have perceptual inference, Bayesian expectation, minimization, like choose Q, the member of the variational family distribution, by minimizing this snapshot f based upon your priors, basically, and new information coming in. And then that takes on a normative interpretation. It's kind of like saying if you were doing linear regression, you would do the L two norm least squares. If you're doing this type of progression, then do this kind of inference. The second one is also normative, but it's action theoretic because you introduced action and then that introduced the elaboration on F to the G function, maybe stephen S, how would you say that this movement into the future first matters for maybe not necessarily how philosopher, but how any other relevant area might see this in an applied context.
38:34 Like what does the F to G movement have to do? Well, I think what's useful is that it's like it's almost taking what's evolved out with the Markov blanket with the expected free energy and bring it back down into a more a form, which isn't only a form, which is involved in the modeling out of particular systems at low dimensionalities coming and saying, okay, this is a broader principle that can

be talked about. And I think that then ties into some of the stuff the active inference lab is trying to look at. How can active inference itself be used as a way to think of organizing and structure our lives? Like George Pereck might have thought about it.
39:19 Stephen S.:
And how can it be used as a heuristic in area like coaching psychology in areas where you're looking at action oriented representation support in complex evolving ways. So you can't model it in the traditional sense of Markov because there's nowhere near the dimensionality can be approached. So what's useful is they say, okay, look, we've got these general ideas, we've got a route to it, but the general deflated forms of that actually then, because they're not so high order and they're not so nailed down to one idea of a mark or blanket, maybe has a more universal application when someone's trying to look at complex contexts and how to act in the world. So I know what your thoughts on that, but that's what I'm very interested in is this idea between sort of diagnostic kind of syndrome based psychology and how do we look at actually what's going on in the context, look at the symptoms, look at the concept encoding and work on modeling using our own apparatus as biological story of collaborative human beings.
40:50 Daniel:
Stephen Dean first, and then Steven. And if you want to give a thought on that. And we're just going to talk about this inference and action piece because I think there's a few more pieces to draw out and then we'll get to the third selection. But Dean, go for it. Yeah.
41:04 Dean:
So back to my strange, twisted metaphor. So now all of a sudden, the philosopher walks into the bar and instead of one map showing up, we'll call it the geometry, which is much more amenable to the model in terms of how a philosopher might walk into a space and see the geometry first, all of a sudden there's two maths. There's a statistical math that showed up at the same time. Are they twins? What's going on here?
41:35 And I think that's where the guide is kind of handy, because if you first walk into the space, I'm not arguing that a Markov blanket exists. I think relationship matters. But I think what most people that walk into that bar don't realize is that you're walking in on two different maths and they're both showing up at the same time. When you were expecting one, you were expecting to be able to work with a model, which is, as I said, it's far more proximal to the geometry math than to the statistical one. And so I think that, again, when we're talking about guides, I can put my hand in the ocean and figure out what the current is and I can look up at the stars and figure out where I am in that invariant space.
42:26 I don't necessarily have to have a laptop with the statistical distinctions. I mean, that might help, but that's not a tool that I need at firsthand. Whereas I think the modeling part, which is what you were trying to bring up with this guide, is at hand. And so it's the availability piece that I think philosophy are trying to.
42:51 Stephen M.:
What. Did I walk into here that's essentially what am I walking into and what is the between us of those two types of math that they're probably if they're like me but I'm not a philosophy, they're asking when they're being introduced to this. So I'm just curious again if I'm going way off on a agent or if we're introducing something, we actually know what we're being introduced to. And that's the part where Stephen used to talk about slowing down, because I really agree. It's not a breaking down, it's an actual flow down.
43:25 Dean:
Nothing wrong with that. Whoa.
43:30 Stephen M.:
I mean, I could try and approach an answer by sort of extending your metaphor if you'll give me a license to do. So imagine you're going to the bar and there's dozens or even hundreds of maths or different components of maths or different approaches to maths, and what you'd really like is some way

of paring that down to something that is approachable. You know, that only a few of these will be approachable, but you don't know which ahead of time. I'd like to think that you could use what we've written as at least the first step to pairing some of that away. So what we've left out essentially is the stuff that you could pair away and say, I can't approach that yet.
44:19 What I know I can approach is these first few things. And what I like to think is that we've done okay at getting at least some of those first few things in there. Not too much, not too little, just really trying to find that Goldlock zone. And those will be the ones that are approachable, even approachable for a philosophy who chaos met very little Mets before. And I owe Steven S a response to your early question as well.
44:48 But if you want to go ahead first, Stephen or Daniel, you say, well, yes. Steven, let's go for it. Yeah, I was just saying maybe bring up slide 13 if you're able to, Daniel, because that might be a useful one, just as it has.
45:06 Daniel:
I have it. Yeah, cool, because that's got a little bit there about the penalty for overfitting penalty for failing to explain the data.
45:24 Stephen S.:
Maybe I'm looking at the numbers at the bottom. Okay, but on page 23 yeah, 35 here. Yeah. Okay. Yeah.
45:35 Slide 21. Yes. This definitely juxtaposes the F and the G. It's like a Pokemon evolution, but it includes those different pieces about bringing in action with the uncertainty on the consequences of action and the fundamental and the ability to impact it. But that was actually what I had kind of written down.
46:04 Daniel:
So Stephen made the point about how action is a lower dimension space, and that's like making an algorithm trackable, like conditioning inference on action, which is something that's very different structure than a lot of other control theory where the target of inference is a policy selection. Here the affordance play a little bit of an upstream role and they make the downstream calculation conditioned on action. So that speaks to a different embeddedness of action in active inference. And then there's a few other things. But first, Stephen M.
46:42 What was the answer that you owed the other Stephen? Yeah, I mean, I was really just picking up on the point that Stephen made about the difficulty of accurately modeling. And we talk about this a lot in philosophy of science, I mean, in the philosophy of any of the special sciences, but in the sort of philosophy of science more broadly, one of the biggest topics is modeling. And one of the biggest questions is how do you trade off between getting a model which is a perfectly accurate representation of the thing that you are modeling versus something that is tractable and that you can handle. And the analogy is always made with maps as sort of the first analogy.
47:24 Stephen M.:
You can't have a map that is an exact replica, excuse me, of its territory because you wouldn't be able to use it to navigate. It could not provide you with anything that was more helpful than the territory itself. So we have some kind of practical knowledge of how to make maps. We know what to leave out, we know how to condense it. We should at least, you know, shrink it usually if we're creating a map from a territory.
47:53 What we don't really have in a very general sense across all of science. Is a set of principle for how. Given a specific situation that is too complex to produce a perfect representation of what thought to leave out and what thought to keep in. And how should you transfer that space into a representation of that space in order to produce a representation that is a useful approximation of it. So the question coming back to the formalism would be how do you choose a kind of a Q distribution, your approximate distribution, the thing that you're going to harboring your brain and believe that throws out enough

of the useless stuff of the real world, but keeps in enough of the stuff that you really need to keep in in the world.
48:41 This is sort of the one of the big questions in philosophy of science, and I guess science proper at like the early 21st century.
48:53 Daniel:
Awesome answer. Thank you, Dean. Ethan Bleu. Yup. Just real quick.
48:59 Dean:
So Daniel, when Daniel talked in the .1 about the third P bit, he called it the PH, itness the fitness. That's what basically you're describing. How do we take zhat variance field and collapse it down to something more tractable, as you said? And so at some point later on, either later on today or in our next livestream, I think that's bit the active inference model, which is not a map, and it has probably two parts, it has a frame, but it also has a filtering effect. Maybe we can talk a little bit about that because that's what the fitness is really about.
49:45 So I'm looking forward to sort of diving a little bit deeper on that because it's not just a back and forth across and reaching edges, it's actually going deeper into and then returning from. So yeah, I'm kind of looking forward to that from a mathematical standpoint as well. Thanks, Dean Bleu. So that's a perfect segue fitness Hinton what I was going to bring up. And so Steven, something that you mentioned earlier is like your attempt to capture the essence of the FEP and the things that will not change and kind of build slowly incrementally.
50:31 Bleu:
And so if we have a theory that does not change, essentially does not evolve, it will die, it will become extinct because we're constantly learning new things. And so from a counterpoint think that it's kind of critical to capture the evolution of the FEP over time because it really changes the potential implication and ways that people interpret the principle and the theory of acts of inference also. And so if it doesn't change, I mean, will it not ever change, or is it subject to change? Or just what are your thoughts on that? Is it totally inflexible these points that you attempted to lay out?
51:27 Stephen M.:
No, I mean, yeah, that general point is very well taken indeed. I guess I think that by trying to capture something that we thought wouldn't change, I think we meant or I should have said we're trying to culture the parts of it that the rest of the framework will continue to depend on for sort of as long as possible. We try to keep the most stable parts of it without necessarily implying that active infants could survive without these mathematical components, but just that the change to the theory or the change to the approach would have to be so radical once you've got rid of these core mathematical components that someone could legitimately ask, is it still the same theory? So that's roughly what I would mean by essentials, such that if, for example, tomorrow Friston were to say, we don't need to talk about variational inference anymore, or we don't need to talk about minimizing expected free energy anymore, someone could legitimately ask, okay, is he now talking about a new theory that's no longer active inference? Is it so different because he's thrown out that sort of fundamental part, that he's now actually proposing something completely different?
52:47 I think that someone could legitimately ask that question. I think Zhat, a reasonable person could say that he's now talking about a different theory because I think that those mathematical parts area so crucial to it, as opposed to some of the other parts, which seem some of the more complex parts seem more dispensable. You could throw out some of the more complexity things, keep these more basic things, and you would still more likely be having the same theory. Ya Bleu so just to respond quickly. For me, that's kind of an arbitrary line in the sand.
53:24 Bleu:
And like one thing we talked about back and forth a lot is this concept of ergodicity. And like an ergodicity system versus like a nonquilibrium steady state density locally ergotic, what does it mean? And if we throw out urban density and eliminate this requirement, is the theory still the same theory?

And so that's one point. But I mean, there are many points in the minimization of free energy and so on and so forth.
53:50 And so as we add on to the theory, we are changing the theory all the time, like as new papers come out, like the recognition model versus the generative model and Bayesian mechanics and stationarity processes kind of really highlighting a couple key points. But as the theory goes and changes, it's like, at any point, we could say, well, that's not the same theory. And so if the theory is not allowed to evolve over time, it's just this arbitrary point in the sense that we don't want to cross, like, the minimization of free energy. What if we decide that the minimization of free energy means something totally different? Even in this paper, you have enough footnote about the complexity versus accuracy bit to refer to free energy as accuracy is, like, I've not heard of it described that way before.
54:40 And so for me, it is this complexity and accuracy. And I understand the way that you framed it, but it's a completely novel way to talk about free energy. Like, I always hear about as infrared in terms of, like, uncertainty or surprise, but not inaccuracy. Like, that was completely, like, took me off art, actually. So, I mean, as the theory evolves, what's the irreducible component of the SPP?
55:10 Does such a thing exist? Or is it just turtles all the way down? Yeah, you're asking me the really hard questions. I like this because it's tough. It's really tough to think honestly.
55:21 Stephen M.:
Yeah, it's tough to think and answer that and to ensure that I'm answering sort of honestly as to what I really believe, as opposed to just trying to sort of dismiss what you say, you know, I'm not trying to dismiss what you say. I do think zhat the line is blurry, so it's not clear and distinct. I don't think that it's arbitrary. I might be wrong in that, but I don't believe that it's arbitrary. Let me just leave to the side for a moment the description of free energy as inaccuracy.
55:53 I'll come back to that because I'm interested in picking up what you think about the different interpretations of the function f. But I'll try and go back to sort of the idea of herbicide.
56:06 There's a sense in which things are still being worked out. And one of the things we put in the paper is something that we were urged to make clear, which is that active inferences are work in progress. Even the sort of mathematical underpinnings are still being fleshed out in a sense, or still being put together in a way that helps connect the different parts of the theory. Okay, that's okay. That, in fact, was a little bit difficult for me to swallow at first because I felt that if that's true, then it doesn't legitimate all of the strong claims that are being sort of made, but all of our complaints about that are in that fourth section of the paper.
56:47 So we tried to make clear what we think is sort of justified and not justified on that basis. But it's still true to say that it's fair to have a framework and to expend time trying to put together the mathematical underpinnings of this framework, even though they don't yet exist. We shouldn't just throw out the theory or disparage Bit just because the full math hasn't been worked out yet. I agree. We should allow it to change.
57:08 We should allow it to evolve. We should allow bit to be applied to different things and see what works and what doesn't. With all that being said, I don't think in this particular case, maybe it's true of other theories, but for active inference, I don't think that it's true that there are things that you could remove and still reasonably say, yeah, this is still active inference. I think a theory could not be Zhat amorphous and still be sort of treated seriously as a way of pursuing science. I think that you would have to say if you throughout minimizing variational free energy, or you throughout minimizing the expected free energy or some other of the core components, I think you would have to say, if you're being reasonable again, the word reasonable is doing a lot of work in this paragraph that I'm building up to.
58:03 I think you would have to say, okay, it's a different theory. I think you'd have to say, okay, we were wrong to pursue the minimization of variational free inference of variational free energy as a principle for understanding the behavior of biology and cognition. We were wrong to pursue that. We're going to pursue something else instead. And so you couldn't just say, oh, it's still the same theory, but

we've changed this core component of it.
58:25 I don't think that line is arbitrary. I think there are some things that if you change, you have to sort of admit that you're wrong about that approach and go on to something else. That's sort of my piece. I've thought for a Realm client, I do want to pick up the idea of free energy as a function that measures accuracy, but I don't want to talk for, like, a huge amount of time. So maybe I should put a pin in that and we could potentially return to you later.
58:49 Daniel:
How about first free energy selection? Stephen M. Finish that three, then as accuracy, then I have a point. Right, great. Yeah.
59:02 Stephen M.:
I forgot we were only two thirds of the way through our descriptions of the free energy principle. I'm sorry. So free energy principle for selection. Let me try and pull it up here so I can just read it directly off the page.
59:16 What we have it as is any system that survives long enough will act so as to appear to be minimizing. F. One of the issues here is that we've left out G, but for the sake of sort of focusing our attention, we can just talk about Zhat.
59:37 Daniel:
Okay. And then
how about the FEP or free energy as inaccuracy interpretation? Great. Yeah. So this is something that I was hoping would be, again, a way to present it to philosophers so that it would be easier for them to grasp what was going on.
59:57 Stephen M.:
I wanted them to understand, why do we care about this function F? Why do we care about variational free energy? Well, suppose that I tell you that in order to do inference, what you ought to do is minimize variational free energy. And then you could very well say why? Why should I care about minimizing this thing?
1:00:14 And then if I tell you, oh, it's the measure of the cost of being accuracy in belief, then you immediately say, okay, I understand why I would want to minimize that because I want to maximize my accuracy. So very simply put, it's a way of explaining why we should care about F. It's a measure of inaccuracy. I think that Zhat interpretation holds up just to the extent zhat if you look at the two components which can be sort of thought of as a cost penalty for overfitting cost penalty for being inaccurate, there's a part of that which is inaccuracy. It's not the whole story, of course, because the other part is to do with complexity, not just to do with accuracy.
1:00:53 So what I think we've done by describing free energy as a measure of inaccuracy or the measure of the cost of inaccuracy is trading off that sort of ability to enter into understanding the maths for a perfectly clear and mathematically very precise way of describing it. But I definitely think that it should be thought of as containing a term which is a cost of inaccuracy.
1:01:21 Daniel:
So we talked in the zero about it's, kind of like finding the shape from the data and the fitness of the mesh. And inaccuracy in the real world kind of has elements of both, or at least we're used to thinking about complex decision tradeoffs. Like you could make a bad decision because it took too long, but then you came to the right outcome in the scheme of thinking bigger than just one p value. And so it's kind of opening up even this very kernel piece of the puzzle to the whole question of how specific and how many subgroups and always leaving space for not overfitting, given this whole map territory for his discussion. Steven S.
1:02:10 Stephen S.:
And would you say that the overfitting accuracy is more around when you talk about adaptive active inference. Where there's a way to adaptive look and have an idea of beliefs in some way. And underneath that there could be a kind of a more action planning mind of entropic mind of process

which is settling plant the background. But in terms of how we normally explicitly think about meaning. We would think about it more in terms of what can be understood as beliefs.
1:02:49 So I just be interested in how you set that from a philosophy point of view.
1:02:57 Stephen M.:
Well, one of the things that's still unclear to me about the overfitting part of F is that it seems that it can only be interpreted as sort of a cost of complexity if what you already believe is simple because what it's really measuring is how far you are straying from what you already believe. So, Zhat, there's kind of an implication there that everybody always has simple beliefs in the first place and that therefore they ought not stray from those simple beliefs. One of the things that I'm trying to think about now is what happens if you are starting with sort of more complex beliefs. Maybe that's not a sort of appropriate question to ask given the framework of the way we're supposed to interpret the math. But I can't help wondering it, given that it strikes me that in order to interpret it, there's a penalty for complexity.
1:03:57 You have to say you have to assume that what you're starting with is simplicity. And I guess there would be real life situations in which you don't start with simple beliefs. And then presumably this would tell you, well, if your beliefs are complex, then they ought to stay complex because that penalty is a penalty for straying from that kind of complexity, which seems different from how it's usually described. Yes. Steven S and would you say that that falls into our more recent move from science as creating models and fitting things to those models in the most simple way to be in modelers like with postnormal science and even fristen's work with the COVID So there's a belief in engaging with a complex nonresolvable system question which is different to science's traditional role, which is to phase an answer and to fit things to it.
1:05:06 Dean:
Well. One of the most exciting and sort of scary aspects of active inference is the idea that it's applied not just as a way of understanding what our target systems are doing. So not just as a way of understanding what a biological system or a brain that I'm studying is doing. But also as a way of understanding what I myself am doing when I represent that target system in order to try and understand it. You get a kind of loop in a way, in a sort of sense in which you feel as though you could model your own activity by using these technical tools which active inference is giving you.
1:05:50 Stephen M.:
But then you feel like, how could that be done? In a way that doesn't invite any kind of infinite regress. That's why it's scary as well as encoding. It's exciting because it seems to potentially provide some kind of extra power or insight into our own activities as scientists or as models of any kind. But it's scary because it seems to then drop you into a kind of spiraling hole of the modeler who is modeling himself, modeling themselves, et cetera.
1:06:17 That's something which I can't think around even informally, let alone try and get to. The portalism of bit zhat was the very structure of paper number 36. So even in its qualitative application, just at the terms and concept level, it does turn the mirror back and that is speaking to the pre and post or reference distribution aspects of Active, all the funny things that Dean says as well and the strange loop there. So what that made me think of is like the statistics and then the famous quote like the statistician can come in for the postmortem or something like that. But a lot happens before the statistics happen.
1:07:04 Daniel:
Like the design of the experiment and so the optimal experimentation and then the knowledge that it will be passed through a distinctions filter in the big macro of the scientific method. Like planning months in advance for how many minutes and hours one is going to count insects or how many microliters of a fluid they're going to move. That is sort of the implementation phase and then there's a design time. And so that's also what ties science to engineering in a way that hasn't been in design thinking in a lot of other areas too. Dean.
1:07:42 Dean:

Yeah, this is awesome. So I dean one of the things that we talk about is some of those density questions around what's the linear aspect of bit and what's the solenoidal aspect of it. And we also talk about walking into a room of mirrors with a mirror suit on. I mean, it all comes together in the sense that I think one of the things that Stephen Mann pointed out is that there are, I think, theorem area. One of the things I think we can say about Active inference that's consistent is that it has at least a minimum of two in that back and forth, up and down the density bump and around the density bump.
1:08:20 You can go either direction. And so that has me asking whether every time we say that this is a framework. Whether we're only giving it half its due. Whether it's a framework and also a filtering exercise. Like does there have to be a minimum of two.
1:08:39 Not just the boundary. But then what is actually going on dynamically within that border so that we know when we're crossing. When we know when we're within the boundary that we maybe are looking at empirically. Right. Because we selected our unit of analysis.
1:08:56 But then when we know when we've crossed outside, that when we've gotten to a place where the mesh is holding certain things back while other things that are of a smaller circumference are still able to sort of pass through. And so I think as a guide, that question of as we model, as we model the model is the minimum. I think if we just say the model, we don't do it justice. And if we just look at that as we model the act of doing that, I think again, we're looking at sort of a side of beef and expecting to be able to milk it. And I don't think that that works.
1:09:38 I think you have. To have the whole thing or else you don't really have an active inference.
1:09:46 I think that's kind of where we're at when we're coming to the place where we're trying to decide what goes in and what doesn't go into a guide and it's a struggle, right there's, no question. It's probably one of the hardest things that you can do because the majority of people that our guides are there because they've been there before versus the one who hasn't. And that would require upending Zhat basic premise, which is no, everybody has to get into the boat and we're sailing off onto the event horizon. That would be the only way that we would change that. So the actual nature of guides would only change if everybody had to get their skin in the game and start at that basic place of not knowing.
1:10:32 But Zhat will Laje that for another livestream. But at this point that's what's really interesting here. One of the assumptions that we made is somebody has taken the time to go and search and explore and come back with information and the other people don't have it. And the only way that changes is if everybody gets in the boat and sails off in hopes that they don't come to the edge of the cliff and fall off.
1:11:03 Daniel:
That's a lot there. Thank you. Dean, just a few other points. People have different perspectives on what is core or not some of the uncertainty. Let's get at it with the ontology development and making some definitions and transition and the formalisms clear in the history of science and all of that.
1:11:23 But even then it might be pretty fundamental. Like if it includes action and inference, these variational methods necessary. So who knows, people will have different interpretations, just about a lot of things and so that's again, all part of the fun. So Stephen.
1:11:47 Stephen S.:
So one question I'd be interested is talking about guides in terms of that book Life A User's Guide. That's a very deep I read it for a long time and then I lost bit. But it's sort of like it takes you into all these aspects of people's lives in that Parisian neighborhood and it never gives you an answer. But in some ways it's leaving it to your intuition, it's leaving to your interactions and I'm wondering where you see that integration that's happening at a perspective level. The integration, the intuition, the affective consciousness that is part of our knowing and how that relates to this and maybe if it's even something that's not part of science but is part of this kind of work.
1:12:47 Stephen M.:
Well, I mean, firstly you sort of crack the code in a way because the title of the paper was directly and

explicitly stolen from the coherent book. It wasn't necessarily a sort of the best joke because in the sense in which the book is about an incredibly hyper specific and detailed description of a system, an apartment block a specific time point on a specific day of the year gave me the idea about, okay, it's not true that we ever really represent things that way. It's not true that science intends to represent things that way in the way that Parse does and is sort of making fun of. But also he's incredibly constrained in the way that he wrote the book. As I understand, there's some really crazy games that he plays with language in writing it and Zhat cause, for example, translators a huge amount of difficulty in translating it because how do you translate the game that he's played in French into a game that you can play in English while writing the English version of the novel?
1:14:00 So definitely the idea of representation and sort of naturalism was on my mind. But the short reason we call it that is because we wanted a punchy title. We wanted something that people would think was accessible. But definitely when it came to casting about for Punchy and accessible titles that was the one that primarily came to mind when it comes to sort of affective consciousness and sort of experience. Again, it's a little outside my wheelhouse.
1:14:32 I was very, very impressed upon by the novel even just in English translation because I can't read French. I was really sort of moved by it in various different ways intellectually, emotionally and things like that. There's a lot about sort of representation in there just the concept of representation and not something that I'm interested in. But again, that Bull sort of in the opposite direction from enactivism or effective consciousness and things and very much situated in that kind of formal, dry approach to philosophy. The kind of anonymous tradition where we try and chop things down.
1:15:10 We think we're scientists, you know, inspecting the human condition under a microscope and so bit you know, I can't deny that in reading a novel it flows over me in the same way I'll experience it. In a similar way that you experience it, I hope. Yes. Bleu.
1:15:31 Bleu:
So totally funny. I was also had a question about a guide but on the opposite of like Life Users guide. I was reminded of the movie Beetlejuice and the couple dies and they have this handbook for the recently deceased, right? Like the core of the theme. Well, did you read the guy?
1:15:50 Well, did you read the guy? Because it's apparently like a very thick, dense book. No, we're dead. We don't know what to do. We're freaking out.
1:15:57 We don't have time to sit down and read this book. And so I was branded that just mind of totally justification. But it's like when you are creating a guide, it's very difficult to make it usable, right? Like the math versus the territory. What will people read and be able to take away and walk away with some kind of general understanding versus if you really want to know what to do when you're dead in this situation.
1:16:24 You've got to read the book how to Haunt the House and all these things. And so do we really need to like Bull grip of the feet to really sit down with those eyes? You know, whatever. It's like 3000 page manual or how do you distill the essence of something that's so complicated? Like what is it to be dean?
1:16:47 Or what is the FEP? Right? It's hard. That's such a good example. It's a handbook for the handbook for the long lived.
1:16:58 Stephen M.:
I guess the free energy principle as opposed to handbook for the recently deceased. Yes. What is the line that they have in Zhat? It's something like some incredibly dry statement which is absolutely no help at all. Like operations parameters vary from manifestation to manifestation or something.
1:17:16 And yet, I mean, the idea behind it was that the philosophers that we talked to that urged us to try and research and write this were pointing out that when they attempted to read those papers in the active reference distribution, even those that were billed as tutorials, it was like trying to read the Handbook for the Recently Deceased. It was, if not too long, then at least too dense. And they couldn't pick apart those statements because they were too condensed. And so, yeah, the difficulty was

unconvinced it, pulling it apart, selecting what was necessary and then presenting it in an accessible way. I mean, all I say is that it took sort of on the order of years to do it.
1:17:59 We sort of got commissioned, as it were, in 2019. I started researching it in earnest at the beginning of 2020. It went through a few drafts and people gave us a lot of comments behind the scenes. But the first preprint came out in December 2021. So yeah, for me at least, and for us, the authors, it was that difficult to trawl through the literature, mind what was necessary and then present it in a presentable way.
1:18:28 But that's such a great example. Thanks so much. That hadn't crossed my mind, but I love that film and the concept of the handbook as well. So just a few comments on that. It's not called free energy principle.
1:18:42 Daniel:
A user's guide. It's actually very specific. It's about the variational free energy and the expected free energy f and G perspective. What's the FEP? So that's sort of where it takes you and it's very subtle then.
1:19:01 That was pretty interesting handbook for the Long Lived and it reminded me about recognition and learning and about what we expect and prefer and think we can know and how just being a learner and like a teacher's assistance, seeing how there'd be lecturers that would give maybe it could be thought of as sort of an EFforty framework another day. But they would simplify and learners would have high precision on a very simple model and then other times they would convey too much of the complexity and so at the end of the quarter, even if the students learned a ton and they would still feel like lost in a bigger space and there's like good and bad aspects of all of that. So I think this is kind of like a snapshot. It's kind of cool that it is so recent. That was only a few months ago, right now that it's February 22 but this is very recent and still kind of ongoing that you're looking to update it too.
1:20:09 So it's sort of like a kind of window where there's interactions with the community and hopefully people really think about it and the people for whom a section isn't clear have an opportunity through this affordance we have now as scientific publishing with preprints like to ask or correct or you missed a citation here that is awesome. And it's a world apart from sort of three people with it on their desk who are delaying it in review and then maybe they have good comments, maybe theory don't. But here there can be something that's so much beyond that as this is just like one thing that you're working on and you're developing and then one last comment on that is like SPM, the textbooks are still kind of classics, cold classics, we might even say. And it's not that the notation hasn't changed a lot because it has in some cases it's a snapshot and there's some amount of linking back to the past that's clarifying and then there can be an understanding that there's drift and focus and evolution of techniques. And the SPM textbook, it's going to have sentences that you wouldn't include if you're writing it today.
1:21:23 Great. That's why it's different. But also there's something about it that helps inform. So every snapshot that's well intended always is good. Dean yeah, I think one of the other things that's really interesting about this is Steven Ms kind of pointed to the length of time when the question was posed.
1:21:45 Dean:
Can you can you summarize this for us? Can you synaptic this for us? Basically what the philosophy sounds to me is what the philosophers were asking was can you go and do the figuring out and then present that to us in a finding out way? Will you save us time? And so I think that's one of the things we have to keep front of mind when we look at this because those philosophers now didn't do the two years of heavy lifting and searching and foraging.
1:22:16 That's a whole different aspect that figuring out is a whole different processing method and mechanism than the finding out, right? And so again, if you want people to come away from guide use with more than the finding out, they're still going to have to get in the field and do the figuring out themselves. And it's that interaction part which thank goodness for Bleu and beetlejuice because again, that was just a wicked example, right? Because the timing of this, the fitness of this really, really matters. And I know that in a lot of educational settings, time is at the essence, right?

1:23:01 13 weeks, x number of hours, blah, blah, blah. We tend to get that that's the only part of the Wednesday that we focus on. Not should the guide or the plan be the thing that initiates all the action or is that the thing that falls out afterwards. If we're doing figuring out, it has to fall out afterwards, not before. And we have a really hard time with that because traditionally it's always been the legitimizing of guides because they've been there before and they'll help you find out, but they don't necessarily help you figure out just because of the amount of time.
1:23:49 Daniel:
Yes, please. Stephen M. So both of the things. That you both just said, daniel and Mendeen, like, they both open up huge topics which have so many interesting questions and so many interesting ways of approaching them. Dean I think I agree 100% with what you just said.
1:24:15 Stephen M.:
They're going to have to use our guide as a kind of shortcut in a way to doing the initial stuff, to finding out, but it behooves them in a way to do some extra work of figuring out afterwards. The thing that Zhat most sort of resonates with me regarding is just the idea that our mandate, what we had to do in producing this was give them the ability to work through like the examples themselves. Because that's a part of I mean, I'm not sure how you're distinguishing these two things, but to me that's a part of figuring out as well as just finding out. To me, we're not just saying this is a measure of inaccuracy and this is the algorithm by which you minimize it. We're saying, look at this example with these numbers in the imaginary situation and if you work through it and if you print out the graph yourself, you will find that this is where the minimum lies, for example, and you will compare that with this other thing.
1:25:21 So we're doing the first tiny step in helping them figure out how they would figure it out in a way, if you see what I mean, giving them the means to go ahead and do it again themselves in a different kind of situation. But the other thing that bit brings up, I mean, I shouldn't say that, like Michael Weisberg didn't say go and do this for me. Go and be my research assistant for two and a half years to print this thing. He, along with Peter Goddess, who was another person, not connected with the Journal in that capacity, but very interested in having this framework explained for a wider audience, pointed out that first and foremost we ourselves would get some kind of like plaudit force, having done the work, having helped people to understand it. So there was the personal selfish incentive to do it but also that it would be something that would benefit the community in a positive way.
1:26:19 Not something that we would be giving them for free, as it were, but something that we would be creating for everybody to draw on and use and just improving how the community approaches this question. So in the same sense, in which in the best case, academia is a wonderful collection of people who are all helping each other to find those shortcuts, do the finding out without going through however long it takes to sift out the stuff that is not necessary. We're all helping each other to do that. I can read somebody else's paper who was working for two years on something completely different and having split up that labor, divided that labor up, we can both sort of benefit from it. Sorry, I'm going on far too long ago.
1:27:08 Dean:
No, no. I'm answering one question. One last thing about the minimum of two things, though. If we could get you and Conor ines into a live stream, I think my mind would be blown just because that math and this philosophy in one proximal location, because that to triangulate off. That would be amazing.
1:27:31 Because that's essentially what you have to do. You have to put the finding out. And figuring out together. I don't think again, I don't think it's one or the other. I think it's our ability to sort of be able to hold up both at once and appreciate how each of those things fills in the picture.
1:27:48 Stephen M.:
Yeah, and I do want to daniel, you should tell me when I should stop or please just jump in and talk me. No time. But I just wanted to sort of respond to your points as well. The other good thing. Since I'm in an optimistic mood about academia.

1:28:02 Like you say. The kind of prepublication preprint sending it out and enabling people to give us comments back on it. If you think about it like that metaphor with going to a classroom and teaching before you go in and teach. You have to pair away all of the nonsense and stuff that's too complex. Get it down to the level that's simple enough so they can understand but has enough information so they can actually learn something.
1:28:26 In the really good case of getting a kind of course evaluation. You do a whole course. You get a bunch of students tell you what was right. What was wrong. What went too fast.
1:28:35 What went too slow. And hopefully there's a kind of average where it averages out and you improve it sort of next time you make it easier for the learners because the learners have told you what was right and what was wrong about it. It's always that kind of feedback process. Obviously, in real life situations, bit doesn't always work that well getting that kind of feedback. But if you're sort of lucky enough to start off from a decent point as I think we have at this paper you can get to a kind of point which once it is snapshotted because that's the other important.
1:29:12 I think that this kind of implication. Peer review is really useful but there shouldn't be constantly evolving documents all the time. There should be some kind of snapshots. Once it's snapshotted, it's like it's as good as it can be at that time. Even if it becomes redundant eventually, even if it uses language which won't be used in 1020 years, once it becomes something that people can refer to valuably for some kind of certain amount of time afterwards, that's really the best that you can hope for.
1:29:41 Certainly just a paper. This is just a paper. It's nothing more than that, really. Just one thought on that, like on the finding out and figuring out, connecting that to the peer review. It's almost like we're all co learners in participatory engaging education.
1:30:00 Daniel:
So we want to make it easier for the learners. Which is us and we're all co learners so sometimes we find out that would be somebody with more domain expertise giving us the feedback on the paper and then in the side channel. Maybe there's another time and place where it's a different roles. Not relationship and then there's the figuring out and then maybe there's other things here too that's actually not like feedback from the bottom up but beginners questions. Abductive logic applications.
1:30:30 Adversarial or contrarian. Even questions that is always like what is active inference? Why does Zhat matter? What does the FEP have to do with active inference? What does evolution have to do with natural selection?
1:30:47 What does natural selection have to do with drift? If those were not resolved then there area going to be some open ones in this area as well. And I think there is also another analogy with sort of like in concordance with evolutionary theory and like Darwin's dangerous idea dennett and 95, that type of book perhaps has already or soon will be written for something like FEP because it has that same ability to like spawn an adjective and then reintegrate the adjective back into the corpus. So Bit was like there was like evolution of this type and then people add like a modality or a domain or a new word and then it rejoins the main thread. So we have like deep reflective, sophisticated contrastive but it's going to reintegrate because it will be versioning and that returns to like blue's point about what is core, what isn't and how will that change.
1:31:46 And so and then you just kind of close the loop with the snapshotting but the recognition of the process but we have to make the static modification in the niche. But of course it's a process. So it's really interesting where we've gone today. Yes, steven M at NS.
1:32:12 Stephen M.:
Oh yeah, just very quickly, I think the point about contrarian questions is a very good one. It's often philosopher's main method of figuring something out, beginning with the contrarian question that is uppermost in their mind going out and trying to find the answer to it. And certainly in this case on my side when I was doing my part of writing the paper, I was starting with what on earth is this maths and what is the interpretation of these different components of it? And that was just for the maths. When

you get onto the sort of philosophy side, the interpretation of the dialectic.
1:32:57 I mean, one thing I haven't said is that there are some quite skeptical portions of this paper you probably noticed when you read it and we tried to pull back a little bit, but what we wanted to do was provide fuel for figuring out and you always want to try and do that in good faith. You always want to do it in a way that's not combative or dismissive. You want to do it in a way that is designed to help you and the person that you're asking come to a consensus about the answer.
1:33:33 Daniel:
Thanks, Stephen. Okay. Steven S. Yeah. I really find this helpful, this fortuitous use of the term guide, because you chose that title which maybe if you weren't doing a preprint, maybe I noticed people area bit more creative with the titles, which then that's maybe
also a nice benefit.
1:33:53 Stephen S.:
But by going there this discussion has been really helpful. I often hear people when they talk about the findings from research that we're going to roll out a toolkit, we do a toolkit. And then when they talk about a guide, it's really story of a guide to teach the toolkit. But here in a way you're looking at, especially if you're getting into the more deeper tacit knowledge is what's the guiding principle to being a modeler? What's it about being a model?
1:34:24 And that's where these kind of conversations are useful. But I think that the type of stuff that's been brought up here are things where they're not resolved down to a toolkit level, but it opens a question for someone to have a conversation about. So I just thought I'd mention Zhat and what your thoughts are about that challenge of someone encoding a practitioner rather than necessarily an academic disseminator.
1:35:03 Stephen M.:
Yeah, it's tough because I'm really not sure in part because all that I'm sort of trying to be right now is an academic disseminator. So I would have to shift into a sort of different gear to think about what it would mean to be a practitioner.
1:35:27 I would start by asking you what you take being a practitioner to be and then see if I can resonate with something in that. Well, for me it's more contextual and it's more about being able to adapt and evolve based on a situation. And often you find the practitioner work is when you're in a face to face performative context in a way where you have to perform either the dialogue. I suppose in science when you're in the field of practice in other areas, it could be the performance of giving a performance be bit a performance as a teacher. It could be a performer being an actor, being a workshop facilitator, being a therapist, being whatever that might be.
1:36:26 Stephen S.:
And I suppose that question about how something being a guide, a toolkit or some way to access the sort of heuristics and ways of knowing which agent even representational in the kind of the way that we can easily externalize. So I suppose there's some of that. There's stuff that we can't take a perspective on directly because we can't necessarily encode it into artifacts and place them in our environment in words, however, that knowing is a skillful practice that has been sort of cultivated. So I kind of feel there's a need for that and there's a big move towards that now with the world trying to embrace transdisciplinarity participation complexity, where you have no way to make any sort of movement forward without the ability to find other ways to hold the meaning.
1:37:30 Dean:
Dean just to sort of piggyback on Steven, I think if you want to try to draw a comparison, if you're disseminated, the result can often be something like a desire line, a wearing in a following. And if you're looking at the generative model, you're looking at identifying at a foraging and then an accumulation. And in that respect, it's quite clear from a practical sense one is not better than the other, but one results in quite a different result than the other is something to think about. And then one other thought on this practitioner and scientist, though I hope we see 100 times more and more different ways

to learn and apply active inference. Just total first thought would be like when Stephen was describing a practitioner contextual and adapting on situations with really lower levels of control.
1:38:33 Daniel:
It's on a continuum, but like a crisis or a transition moment or an adversarial scenario has a lot of an implicit factor and it's not always as focused on like the coolest, calmest, most collected stigma artifact modification. It's more like the firefighting was done appropriately in that scenario, given what it was. And then the scientist generates niches like epistemic niche, laboratory niche, computer niche. Zhat allows them to generate scenarios where they can apply distributions and then when they apply the distributional methods where there shouldn't be a distributional method, it's going to be unfortunately, a Sillett error most of the time because of how little paid attention to all these differences are. So Stephen M.
1:39:32 Stephen M.:
Yeah, this is really tricky to think about, I think. I agree that knowing ought to be considered a kind of skillful practice. That was one thing that you said, Steven, that I really sort of jumped out at me in part as being not sufficiently emphasized elsewhere, certainly not sufficiently emphasized in the tradition of philosophy. Zhat I come from there tends to be a fairly clear distinction between knowing in terms of representational knowledge and knowing how in terms of skill. And there's not that often the consideration of the kinds of things we would usually consider representational knowledge as underpinning a kind of skillful practice.
1:40:22 But when I think about the way that I'm thinking about philosophy conferences and the kinds of conversations that go on. It's pretty clear to me that having a conversation with somebody else about a topic that is so sort of steeped in law and intellectual recognition and tests as having a philosophy conversation is what it requires is a kind of skill. A kind of smooth. Kind of automatically picking out the topics as you go along. Not sort of sitting back and thinking very hard on your own before coming back 30 minutes later and encoding to the thing that you're interface to.
1:41:01 Just said it has all the hallmarks of a skill. As far as I can see. And what happens is cell, the way Zhat I have been brought up to view it is you do all your thinking at home or you do all your thinking in the armchair and then when you come out to have the conversation, you're ready with that skill because you've done all of that slow, solitary work first, the kind of propositional or representational kind of work. Then when you're ready, you come out and you practice discussing it.
1:41:36 Daniel:
Thanks. Great point. It's a lot like the representational dimension is kind of a nonlinear knowledge model which cannot be conveyed in a linear sequence. Linear presentation in idea and in writing is rhetoric. And that was one of the most interesting area in the paper, was like the claims justification, the whole second part.
1:42:04 And I'm happy that we spent almost all the dot zero in our conversation leading up to it because there's a whole paper and it sounds like there's so much more to explore. But the part about the rhetoric and the way that people not just have an edge in their knowledge graph. Their armchair knowledge graph or their relational database. Not just an edge between concepts. But actually when a question is raised to move to that answer first or the first topic that's mentioned.
1:42:39 Like if somebody asks what is a Markov blanket. The first noun. What is it going to be? Well, for a cell? Or is it because of Bayesian?
1:42:52 Or what is the actual first rhetorical node that somebody gives? And those kinds of internal representation are really interesting too. It's not even just that it's the most important thing because that's not how people always structure their speech. So like there's both idea. We need the nonlinear part so that we can actually build a bigger structure than just an oral script.
1:43:21 But then it has to be in that runtime that you kind of described at the philosophy conference. It has to be presented in a linear way and if. There weren't disagreements or like controls in people's perspective, then they would just be reading off the same book.

1:43:41 So maybe would love to hear your thoughts on any of these latter sections in four, like which one of these areas of claims we won't stay long, but just what area, the areas of claims or the relationships between areas was interesting to you or like, you learned while reading about it because you had the justification links between dialectical categories with mathematical empirical in general. So maybe just one edge or one selection of those. What did you find interesting?
1:44:26 Stephen M.:
Was that a local question or you're asking me? I wasn't sure, I guess to you.
1:44:34 I can definitely start with the first section, which was the mathematical to empirical direction. And as you said, for each edge of the triangle, we were only sort of considering one direction mainly for considerations of space. What's most interesting to me about this is just that it is an established research field called computational cognitive science when the specific math that is being looked at is certain kinds of neural networks or other kinds of computational systems. And the specific empirical system that is being looked at is the brain, especially the human brain. And what we really wanted to emphasize in this section was zhat the kinds of tools that have already been developed by computational cognitive science.
1:45:19 So that includes the models and the explanatory tools and the justification or inferential tools could be applied to active inference models as well. So this was our attempt to say to the philosophy, we already have some equipment we can use when what we're trying to do is evaluate active inference.
1:45:48 Daniel:
So whether we call it deflationary or not, there's a lot of relevance in emphasizing which parts are specific to active inference and which ones agent like bringing action into the loop is not a novelty in the last 15 years doing Bayesian statistics, doing variational inference. And so that work helps us really highlight the parts that do have unique and different interpretations. This is definitely one of my favorite paragraphs, I think that we've come across and gotten the highlight on the discussions and then you even brought it up that it's actually in the distillation. There is a novel, not just implicit knowledge or notational connection, but a rhetorical element that arises and then also one with like educational and didactic implications. So that's really interesting.
1:46:45 Dean:
Dean yeah, and I think when I was reading a paper, Stephen, I noticed the number of times you had the word evaluate, evaluate, evaluate, which again is another one of those. Does this pass, pass muster, pass, a standard pass? What goes on and what gets held back? What gets continued attention and what do we now ignore? And that's why I like when you were talking earlier about well, when we put a guide together, we just want to basically walk into the bar and make sure that the 98 things that we really can't pay attention to first that doesn't pass.
1:47:25 What does pass are maybe these two first nascent ideas. And so, again, you don't need to even hear this, but if you want to just a factory link that is one right there in real time in terms of what carries on, what can we build off of and what falls away because it doesn't seem to pass whatever evaluative methods we've applied. But then again, that goes to when do we start evaluating from the moment we started? Do we plant it to be something a little bit more creative and hold that thing open a little long before we jump to agreement?
1:48:13 Daniel:
Okay, so in the last just a few minutes yes, steven, do you want to give a response there, or would you like to have a little bit of a closing statement?
1:48:25 Stephen M.:
Let me give a quick response, which is just that I agree exactly with what you said, Dean. And yeah, we wanted to show that some things could be evaluated very directly just by working through the numbers, and that give some directions for how other things could be evaluated. And you're right, it's like passing. It's sort of how a philosopher evaluates the scientific theory is being sort of, in a sense, first level plasticity or first level acceptability how it passes. That it's kind of a philosopher's technical term.

1:48:56 But I can sort of give a kind of closing statement that calls back to what you just mentioned. Daniel. That paragraph. Which is just that the thing that I'm thinking about most often when I think about active inference right now is the interpretation of P in the expected free energy function and the sense in which it can have a probabilistic interpretation as well as an interpretation of a kind of preference. That is the thing which I really want to try and get to the bottom of.
1:49:29 Again, just by working with very, very simple models, try and throw some numbers around, try and intuitively grasp what that model can represent. We have one in theorem with the example of the cat, but I want to try and expand it a little bit. Yeah, I'm glad that you like that paragraph, because it's the thing that is causing me the most. It's the thing that's itching the most that I'm attempting to scratch right now.
1:49:57 Daniel:
All right, so we'll each give a closing thought. So just what do people enjoy? What would they look forward to talking about next week? So, Steven, first, well, just thank you. A lot for really great, engaging conversation and lots of insights.
1:50:16 Stephen S.:
I'm really interested in that idea of the P's. So I think that's very interesting, and I'd be inference in how that maybe applies both on the sensory side and the action side. So how much is the probabilities and preference for sensing as much as or is it that one is more for sensing, one is more for action, but very interested in all of that. So thank you very much and look forward to more conversations. Okay.
1:50:55 Daniel:
Dean Orblue. I'll go ahead. So thanks for understanding all my interrogations. I appreciate it. If you're going to come back next week, I would encourage you to check out the Tails two densities because like on tails, Steven with the PS and the QS, I'd be curious to think about or hear what your interpretation of that is and if you would maybe change or maybe you will, it's just a preference.
1:51:23 Bleu:
So maybe you have a versioning affordance to kind of consider that in your exploration. In the beginning, I'm curious or if you think it's one of these superfluous extra components that is for the Handbook for the Recently Deceased, not necessarily like the 13 Steps of Dying or whatever. So I'd be curious to hear what. You have to say about that.
1:51:52 Daniel:
Dean, anything? Yeah, it's just that I don't want this to drop down to the sort of quantum level, but I think that when you're doing a guide, it's hard not to sort of try and juggle both the dynamic aspects of what you're trying to share and the stable aspects of what you're trying to share. You want you want the screwdriver to remain robust and constant and then you want it to also be able to be manipulated in such a way zhat it drives the screw and there's a dynamic and a stability piece to this evidence that's really, really hard, as you say, square. I don't know that it can be squared. I think they both have to be maintained.
1:52:34 Dean:
And so my sense is that I didn't know what you were going to do in terms of the guiding, but I think the way that you laid it out did slow things down, did allow the teeth of the screwdriver to get set and then you could actually do something dynamic with it. So I really appreciate that. And Maze, next week we can talk about when the screwdriver is used for creative purposes other than driving screws because I think what the math? If we use the geometry and the statistics and the philosophy all in one concoction, I think that's the basis of the minimum that we have then to be able to do creative things and not just recombinatorial things. So maybe we can touch on that.
1:53:20 I would be really curious to hear how you see this going up in creative ways without going because the big fear people have is that just means destabilization where I'm saying it has to start from both stable and the potential to move.
1:53:39 Daniel:

Thanks, Dean. Steven, any last thoughts?
1:53:45 Stephen M.:
Just to thank you all very much for engaging with our paper, for inviting me on the stream, for asking me really great questions and raising great points that just had never crossed my mind. This is exactly the reason why I was supposed to do this. I am going to try and come back next week. I can't make any promises right now because next week is a bit of a heavy week for us. But just the prospect of going and reading that paper and then being able to respond in a more intelligent way to please question is making me really want to do it not to attention all of the other topics which we haven't talked about yet force the rest of you as well.
1:54:19 So I will let you know know during the week but your fingers crossed back gain next week. But thank you all. Thank you. I really appreciate everybody sharing their perspective and you're welcome back anytime. So see you everybody.
1:54:32 Peace.

Session 037.2, February 9, 2022

https://www.youtube.com/watch?v=6WP7mY13lzc

A second participatory discussion on the 2021 paper "*Free Energy: A User's Guide*" by Stephen Francis Mann, Ross Pain, and Michael Kirchoff.

SESSION SPEAKERS

Daniel Ari Friedman, Stephan Sillett, Dean Tickles, Bleu Knight.

CONTENTS

TRANSCRIPT

00:13 Daniel:
Alright. Hello everyone. Welcome. It's ActInf Lab Livestream 37 dot 2. It's February 9, 2022.

00:24 Welcome to the Active Inference Lab. We are a participatory online lab that is communicating, learning and practicing applied Active Inference. You can find us at the links here on this slide. This is a request in an archived livestream, so please provide us with feedback so that we can improve our work. All backgrounds and perspective are welcome here and we'll be following good video etiquette for live streams.

00:50 Feel free to visually raise your physical hand if you'd like, or use any of our Emoji affordances. Check Active Inference.org to get updates on what the lab is up to and also get more information on how to participants or check out this Koda link. If you like to see our past and upcoming streams, we're here today in stream number 37.2. It's our third stream after the zero background video and the one group discussion we had on the paper, “Free Energy: A User's Guide” by Mann, Pain and Kirchhoff from 2021. And today we have a few things written.

01:36 There's a couple sections of the paper that we didn't get to last time and I'm sure everyone has brought some interesting thoughts. And of course, if you're watching Live, please feel free to add any questions or comments into the Live chat because we'll definitely have time to address anything there. Cell start with an introduction and warm up. So we'll say hi. Mention anything that we're excited to talk about today, something that we liked or remembered or reviewed about the paper this past week, anything that we're wondering about.

02:11 And as we just mentioned before we began, like, what does a dot two for a guide look like? So I'm Daniel, I'm a researcher in California and I'm going to think while others are speaking and then return to what the dot two can be and I'll pass it to Stephen.

02:33 Hello, I'm Steven, I'm in Toronto. Steven Set, I'm doing a practice based PhD around social topographies and how they can be used in community development and theater for development. And yeah, I'm looking forward to looking at some of the implications of how this might be rolled out in different types of context.

02:56 Stephen S:
I'll pass this over.

03:01 Dean:
I'm Dean, I'm in British Columbia at the moment. And as with all things guide related, I'm always interested in how we translate from the word to the deed. Getting from a place of information that's curated to actions that are also maybe curated based on that bit of information. And I'll pass it to Bleu.

03:32 Bleu:
I lost my mute button. I'm Bleu. I'm a research assistant or research consultant in New Mexico. Transported back to my grad school days. I had a mute button.

03:43 Loss of time, war Bull. At the same time. I'm excited to get into the sections of the paper that we didn't really discuss. Like in particular. Like using mathematics to validate empirical claims or justify empirical claims and also kind of zooming out and evaluating this work from the perspective of a guide and like I think about the Hitchhikers Guide and Don't Panic and like what are the things that we really need?

04:13 What area the essential components of the FEP and Active Inference that we need to communicate to others. And I'll pass it back to Daniel who's going to tell us what adoption really is. Well, what it really has been is the far Side of the bathtub, the dot zero. We're kind of prompting into the skating rank and then in the dot one there's an opening and we explore. And last week was an awesome discussion.

04:46 Daniel:
We got to speak with the first author and now we continue but also recollect some of the threads that we open and build inertia towards where we take it next. And I think there's almost no genre more appropriate for a dot two than like I book like you put down in Dean's Car manual metaphor you don't hold that up when you're driving. And so papers similarly they engage our regime of attention transiently. You're not supposed to only be looking at the paper. So we're going to put this paper down, we're going to end this video eventually and then what will be left with us?

05:33 How will our generative model have been updated so that our policy selection are different? Whether they're mental action policies related to attention or metacognition or whether they're physical action policies. So I guess it relates to that quintessential dot two question of moving from the word of the paper that we're engaging in in our discussions to the deeds and what are those deeds? And then it's almost like this is an action oriented framing of a dot two or of just what we're up to today. And then there's this asynchronous or not temporally binding elements of which is raised by the paper though of what are the essential components of FEP and act imp and also the differentiate perhaps between the conceptual and the pedagogical like are the pieces that are the minimal kernel of FEP and actinF?

06:48 Is that page one on the guide? How does education, which is going to be the trajectory of a learner relate to the theoretical apparatus which is kind of like a building or some sort of structure that doesn't necessarily have a trajectory like format?

07:11 So maybe just to return to this question though of the word and the deed in the dot one we heard about what the target audience was from the author's perspective for this paper which was it's a special issue. It's topical collection called The Free Energy Principle from Biology to Cognition and we heard a little bit about how the editor made a request of the authors to write this special piece and they also summarized bit in their last aim we aim to increase philosophy understanding of Active Inference so that it may be more readily evaluated. So within the philosophical domain so that it can be evaluated. But what other domain or ideas are important here? And then what are these actions?

08:15 So philosophers might be interested in reading this so that they can better philosophically evaluate, but what are the idea to deed pipelines that we're interested in or opening up here? Steven and then anyone else? One of the aspects that this paper talked about is how much things can be screened off. How much it gives us latitude to separate out realistic empirical interpretations from the modeling of and I think that's the feature they also talk about and I'm interested in what others think about this. But they talk about the Markov blanket is giving this opportunity to screen or screen out what's inside and outside.

09:07 Stephen S:
And I wonder how this idea of screening because screens are not the same as a wall. It's not walling off. But as come up on the Twitter conversation with Casper Hesp this week, this idea of leakage, like if I have a screen, I've got a blind here as I described earlier and there's some leakage through the blind. Right. Bit.

09:34 Is even that idea of screening off a little bit passive? I'm curious about that. A little bit dead anyway.

09:45 Daniel:
Yeah. If there weren't statistical dependencies between internal and external states, like if there were two states that were just not even there was no path from here to there, there wouldn't even be able to be blanket states partitioned out. So internal and external states are conditionally independent upon the blanket states using the narrow pearl 1988 sense of Markov blanket. But there is a channel, there is a path from the internal to the external states again, otherwise they wouldn't even be part of the same click in that part of the Bayesian graph and then also yes. Steven yeah.

10:32 Stephen S:
So this click, this question of how much we need to find purchase through that blanket and the screening off and how much we can get away with more broadly, thinking about the free energy principle and inference and how that can be stepped up and down depending on where we are in terms of empiricism and trying to make claims seems to feature a lot in this paper. And I'm sensing that because they're sort of arguing in a way that as long as you can get functional correlations, then how you get at them being zhat approximate isn't necessarily about it being the real world that gives you it. There may be different ways to active at something that's approximately useful. And I think that speaks to dynamical systems over traditional systems in the sense that I can have a system which isn't the real system. But if my system flips or the regime shifts in similar ways to the target as opposed to bit actually being bit and having the right types of values in it in itself.

12:03 It's more about what's the way that I start to see my uncertainty flip from one belief to another. If the way the belief updating happens is still approximately useful enough for something to happen that's viable, then that is still okay. I'm wondering if that isn't possible in normal systems work, which isn't dynamics systems work.

12:36 Daniel:
Let's look at the order and kind of trace the trails of the author. So in the early example we had just the parse of perceptual inference which was first introduced in the exact parse concept. And then we moved into the variational Bayesian inference and we had W world states unobserved. That's the actual temperature in the room x observed data. That's the reading on the thermometer.

13:07 So this is the simplest Bayesian latent or hidden state model. So is there a Markov blanket here asking for a friend?

13:25 No, because there's only two notes, so there cannot be a partitioning between internal and external states conditioned on a third note. It's kind of like the minimum two, but now we're taking minimum three. You can't have a blanket in intervening or intermediating or a state which makes two others conditionally independent unless you have three. Threes a crab
three is a party. Now in figure three there's the basic model of action.

13:57 So we still have the same definitions and learning of W unobserved world states and x observation. Those observations are now being passed to the agent and indeed they were implicitly being parse to the agent above. If there would have been a third node agent there, it could have been said that the x was a Markov blanket. But as it's exactly written, theorem isn't. Now here, what are the blanketing states?

14:33 X and Z. If you are conditioning upon x and Z, it makes W and the agents conditionally independent. And this is sort of presaging the Friston position on the Markov blanket which is to split up the notion of the total set of intermediating or conditionally independentizing states, markov to Pearl epoch and showing them in a way that's partitioned into incoming from the Asian perspective, statistical dependencies, which can be interpreted as sense states or the observation of model data. And then outgoing statistical dependencies, the action you select and then those can have some influence on world states. Yes, Steven, now you say outgoing statistical dependencies and that's also interesting because at some point the outgoing cannot be statistical alone because you don't have the same kind of information availability.

15:45 Stephen S:
So it tends to be more using energy and sort of lease action type approaches. I'm sort of preempting that, but that's where it starts to split out later. But they don't get bogged down in that this stage. They keep it all in the sort of Bayesian environment.

16:11 Daniel:
Not exactly sure what you mean since these arrows represent not mechanistic or causal influence but just statistical dependencies in the graph. Yeah, I was thinking more when that becomes action, when it's been translated to the action rather than sensory which has much more informational content action could be seen as being more about what is more energy efficient or starts to look at more the shape of the way that action happens.

16:57 Stephen S:
I'm wondering whether that is needed to be concerned about. If it were a software agent, then these are both informational really, and no matter what type of agent we're modeling, it's still just a statistical dependence. Then you brought up questions about energy expenditure during action and that's one of the pieces that is sometimes challenging to parse out, which is like first looking at variational free energy minimization. So this is on the perceptual side. We're looking at the instantaneous fitting of a variational model of ongoing sensory information given the prior.

17:48 Daniel:
That doesn't mean that for, for example, an organism, it's the lowest energy possible interpretation of the sensory data. And then when we bring action into the picture and look at expected free energy, neither does this mean that the Z that is selected is the laziest. It just means that this g is being minimized. And so it's not the Gibbs free energy or the calories that are being minimized. It's something informational that has to do with model fitting.

18:26 Yes, go for it. Yeah, that definitely makes sense. One thing Karl Friston mentioned in the symposium we did is there's kind of two boundaries. There is kind of two boundaries happening in terms of Markovian boundary, there's one coming in and there's one going out and the blankets kind of got both of those boundaries happening. So like you said, the way that the inference happens to know what action to take is different.

18:57 Stephen S:
But the way that information is established is for sure different going through each of those as it is with every mode of sensory data that comes in, because it could be vision, it could be hearing, it could be kinesthetic. So you've got different types of input and you've got different types of output. Bit theorem and this diagram moments keeping both of those, there's no idea of leakage or those questions about how things leak across between it's like there's two distinct flow going on and it simplifies it in that sense.

19:43 Daniel:
Yes, we've seen other topologies of perception cognition in action, like an edge connecting sense in action states or an arrow that's having a statistical dependency the other way. Okay, but just to return here yes, Dean, go for it. There's a question for everybody here. So the first author talked about the fact that sort of the backstory of this whole guide thing was to and I'm putting words into it, but I want to keep it reasonably short. I talked too much last week.

20:21 Dean:
He basically wanted to be able to remove some of the impediments and he pointed directly at some of the math that acted as maybe a kind of a bridge too far. And so he wanted to make that a simpler, maybe something that's more user friendly and therefore something that people will take up or adopt. And when you're putting on this when you're putting up this slide here now, Daniel, I don't know whether I know it eventually will be translated into the math formalism. You just point you had them up a minute ago. But I'm not really sure whether the evaluation aspect that philosophers are going to then decide whether something is worthy of their continued attention or not.

21:10 I'm not sure if that how does this critical path, critical and evaluation being related in this context, how does this minimize or reduce the impediment nature of what the math is like? If we're going to guide someone through this and one of their hopes is to be able to say. Okay. Well. I'm not just making this stuff up.

21:35 There's actually some way of being able to formalize this. How does that. Through this kind of first step.

21:47 Become easier. I guess. In terms of what the actual formula says. Because I know that when I first actually touched on the formulas myself. It didn't go back to a critical path.

21:59 Like there was no real physical example I could find in the world. And I think maybe that's what helped me understand that. Maybe this thinking or this ability to think statistically sorry, to think statistically, maybe that requires, as Karl also said, our ability to do the math. We have to be able to do the math, and the math doesn't get simple. So I'm wondering what people think about that.

22:30 Daniel:
Okay, Steven, if you have a direct response. Yeah. Cell I think that in some ways, this goes back to a little bit before where the math bit helps us see why the math was put in at certain points by going even a stage earlier. So I think there is some use in that because I think, like you say, there is a slight inflation in the way that the process theory then gets interpretation. And if it's already locked in too much in what's given to us with all the math cell where did that math come from?

23:02 Stephen S:
And then that starts to get us involved in some of these earlier questions, because what's interesting

here is the blanket. I think of the blanket often as a method for transfer. It's a mode for transfer, just bit like lithographic blankets transfer from an analog roller to a blanket roller, to a printed image and to the paper it's transferring. Now, it also does mean that there's no direct contact between paper and paper and printing plate. Right.

23:43 So it's screened off as well. But it depends which way it's gone at, you know, and in this case here with these red circles, it's useful to think about, okay, well, there's something that's been inferred from the world, but that inference isn't directly accessible, that observed data isn't coming in as data. It's coming in as what's inferred to be about what's out theorem, which isn't the same as a signal. So it's like how much is the agent able to have the environment transfer something onto them? And transfer something onto the environment?

24:38 And how much are they screened off from the environment? How much is the environment screened off from them? I suppose that's something that relates to that.

24:51 Daniel:
Okay, thanks. So, Dean? Yes? Do you want to go for it first? No, go ahead.

24:59 Dean:
And then I'll just follow up both you and Steven. Okay. So you asked how does the critical path, the linear pedagogical path that is traced by this version of this guide reduce the actual perceived impediments in an audience specific or in a general sense? So it definitely helps us see where math could or should or does or will enter the picture. I think it sets up an aboutness of the math, like what is perception about?

25:30 Daniel:
This is a graphical interpretation. Graphical meaning visual, but also like a network Bayesian graph. And so if you're concerned with a different connectedness of terms, this is not the math you're looking for. But on the perception side, if this is kind of how you're setting up the template for what you're wondering about, like what's out there? That's what this first image shows with W next, what's out there and how do I act or how does an agent act?

26:04 That's the aboutness, which is not unique to act of inference, that's control theory, cybernetics, et cetera. The stepwise guide element, it reminds me, I hope it's not unrelated in high school crosscountry, the coach would say something like, well, the race is going to start and you dot two, get out there fast. And then it's the middle is the part where you need to be running and going hard. Then at the end you dot two, push it and finish and run hard and everything. And I was like, you could have just said run the whole time.

26:34 Was it not the same thing as saying run at the beginning, middle and end, but run really hard during the whole race? I don't know, coach, a whole race is a long time to run. Here. By breaking it into really specific stepwise changes to the math, like a piecewise defined function, there's an opportunity to parse and lead a learner
and then to accumulate or parse for divergence or prediction error that they're experiencing. Like maybe before this first train stop, someone has a question about that.

27:18 Or maybe just graphically when action enters the picture, somebody has a question about that. Now we could be talking about equations, symbolic equations that describe the W to X relationship or the Agent to Z to W relationship. And then this paper is going to propose just one symbolic expression

or several symbolic expressions that today we call Active Inference'approach to addressing that question. But it builds up the aboutness in a stepwise way that even though it is conceptually no different than just saying. Here's the action perception loop and the equations.

27:58 Which is pretty much zhat every FEP paper does. But by starting somewhere a lot more atomic. It allows the stepwise addition of the math in a way that's incremental rather than like. Here's the apparatus and that leaves much of it implied. Dean yeah, I wouldn't disagree with anything you're saying there, but I do think that there's a dot, two subtle difference between step wise and then the kind of step function, the leaving of the critical path and now seeing a set of mathematical formalisms around a statistical distribution.

28:36 Dean:
And I'm just wondering how that transition occurs because it doesn't seem like there's a natural ramp from following something clockwise or counterclockwise to being able to change things into alphanumeric ratios, which is essentially what the statistic, when it's written out statistically what that does, right? The sum and the ratio. So if the impediment was some of the non frequent math and I'm not critiquing in any way what Stephen's written out here in his guide, but it seems like there's still some assumption on the author's plural part that you will be able to take enough from this critical path representation to see what it looks like when you're overfitting. Like, I like that there was a lot of explanation of what overfitting is and then there was plant and here's the formula, zhat overfitting looks like in mathematical form. So it's kind of a big assumptions that the person who's reading this is going to be able to make that leap go from this level of walking clockwise or counterclockwise to now suddenly being able to understand what all of those different symbols in that formula means.

30:13 I'm not saying it can't be done, but I'm just wondering how, as people who are trying to lay out something in a mind of step progression, how they assume that they can just sort of put holds into that big wall and people still don't have a fear of heights, right? Like it's still better than not having a ladder, but it doesn't mean I want to go up 40ft without safety, right, just because it's there. And I kind of see that in terms of how the transition works between this form of representation and then what the representation looks like in the math. That's a big leap, I think, for a lot of people. Thanks, Dean.

31:00 Daniel:
Steven?

31:05 Stephen S:
I suppose one danger that's always present when naming things is they then move into this with the predictive processing discussion. How much can you name things as being data in these concepts? So it becomes statistical, but like you say, there is effectively information coming in. But data in some ways may be a bit of a tricky word to use because data kind of implies action oriented representation nature and they talk about this in the paper. A little bit of that attention between something that is coherent enough and can be representation and something where you can't ever quite get at that the inference of the predictive processing has to then leverage something like generative model models using the body.

32:06 Et cetera. To even get at the allow that arrow to be something in a much more fuzzy way. You know. And so there is always that risk of leading people astray. Even at this early stage.

32:29 Daniel:
So, a few comments there. Dean, you ask, how do we get from this graphical layout? So we've taken the first bite, which is this is roughly the correct topology for thinking about problems of perceptual

inference and action inference. That is, someone reimagines this amazing, but this is just the approach to perception recognition model action and impact that is a common kernel of a phrasing. Now, let's just think about it as an example rather than just the abstraction.

33:12 Let's just say that we're interested in listening to a cat and then inferring what its exploration is. So we're only talking about this simpler W and X connection first. So here's what the empirical data are. Four, two, one and three. You could have a model of decision making on X that just says the cat is always in the kitchen.

33:40 Just I don't care, I'm okay with being wrong. The cat's in the kitchen. Or someone could say the cat's always in the bedroom, or I flip a coin or I go with what some other person told me. Like there's many ways to make a decision about world state's condition on data. One principled approach, which they right.

34:00 Here one famous method for solving this problem, beijing conditionalization. So that's the question which is framed normatively here about one, what one ought to do is interface their beliefs, which can be empirically grounded, that's parametric empirical Bayesian upon incoming data. So first, in this case, the next little tiny step is we can use Bayes theorem to look at inference on external states given incoming data. Again, if someone disagrees with using a Bayesian approach, an exact Bayesian approach, that's the time to speak their piece. This is a very simple example with kind of the minimum two by two matrix.

34:50 If it was any thinner of a model on any dimension, like if there was only a kitchen, then the question of location inference would be trivial. It's in the kitchen. If there was only one sound equally, it would be a trivial problem because the sound would then be uninformative from an information theory perspective, which they're not bringing up here yet, about location. Then the next tiny step, and then Dean, is to go from the exact Bayesian approach, the parametric Bayesian approach to variational coherence, which is imagine that this was not just two by two table, but there was a higher dimensional state space of observation. And so it's not going to be possible to just look at this in a spreadsheet or on a piece of paper, but it's actually a large model.

35:44 And so we need tractable heuristics. And so that is the next tiny step. From now we're going to take not just a principle approach to treating the W to X relationship Bayesian perceptual inference, but we're going to go beyond that and ask what's attractable and reasonable approximation variational inference. There's other situations where maybe there's another active approach like MCMC Markov brain Monte Carlo. That's another approach which we've talked about in other cases.

36:18 That's the pointolism samplingbased approach. It works really well for certain problems. It doesn't work as well for other problems. And so that's the next little tiny step. We're going to go from this setup of perception to using Bayes theorem, you could do otherwise.

36:32 And then from using exact or parametric empirical Bayes to using variational Bayesian approaches, and again, you could do otherwise. Dean and then set you. Yeah. And again, I think I'm pointing out is that for some it isn't a tiny little step, but I don't think it's a ramp going from one version of representation to four square vision of representation to formulaic version of representation. I think for people who see the math maybe as an impediment to their further continuation of using the potential of the free energy principle, maybe they aren't such small steps.

37:16 Dean:

They certainly aren't ramps in terms of how we interpret each of those three particular ways of representing information. There's no ramp. There's an actual transition moving from what you've got on the screen now to the 60 40, 50 50 way of being able to interpret that way of representing the information to the one that has an equal sign. They're very different. Right.

37:46 I understand the relativity piece. I see that carrying throughout this is what relatively relativity looks like this way and then this way and then this way. But I think the struggle for people who are putting guides together is the assumption that what's little for you is little for me bit isn't always that way. I don't know if we can fix in that here in these labs, but I don't think it's something that we should assume is necessarily one small step for humankind. Because I think the reason why the authors were asked to put two years worth of work in this in the first place was because the math is acting as an impediment.

38:31 Now, do you start with the math? Because I agreed with Stephen last week when he said, this is the direction we took. We decided to slow things down. Not simplify, but slow things down. So I really appreciate why they've done zhat they've done.

38:46 But if they knew going in that they were going to have to go slow, then they're probably going to see whether or not that bump as we change representations is actually relatable to the previous version or form that the relationship was presented as. And I don't know that people necessarily do it like Bleu is going to say on this, too, but she mentioned the arbitrariness of something that doesn't update right. And so it doesn't retain its. Force and should we just assume that we all saw the morphology in the same way? It's tricky.

39:30 I'm just going to leave Bit at tricky because I'm not sure anybody that's putting a guide together necessarily has the perfect way of being able to deliver it. Okay. Thanks, Bleu. And that's you.

39:47 Bleu:
So something that I think is interesting is the mathematical interpretation have like philosophical underpinnings almost or maybe it's the other way around. So when you're looking at like, for example, this difference between a probability distribution and a preference distribution, like if the cat is in the kitchen 75% of the time, you can just assume there's like the underlying assumption that it prefers to be in the kitchen most of the time, right, because that's where the food is or whatever. And similarly in homeostasis, if I'm at 37 degrees Celsius, that's my temperature. If I'm there 95% of the time, you can assume that I have a preference to have a body temperature of 37 degrees Celsius. I think that there's that underlying connection bit it gets really complicated when you try to extrapolate to something like cognition there's like I prefer to be rich, I prefer to have 90% of the money in the world.

40:57 For example, you can say I want all the money. You think about something like that. But then there area so many complicated like do I really want all the money? No, because then everyone else would be homeless and impoverished to be horrible. Right, so you don't really want all the money.

41:15 Say if I prefer to be rich but I'm stuck in an impoverished situation. You can assume that there's like a learning gap between how do I earn money and being in the space where I don't have any money. Like I don't know how to have money. Like there's a knowledge level. So when you bring cognition into it and you ask people what their preference are, I prefer to live by the beach, but I live in New Mexico.

41:37 I mean, we have lots of beach but no water.

41:42 I don't know, there's the preferences and then the probability. But if there's some kind of cognitive dissonance, you think we think what our preferences are or maybe not where our probability distributions are. I prefer to be by the beach, but 90% of the time I prefer to be by the dean, but 90% of the time you find me in the desert. There's some cognitive dissonance going on there. And so I think that the mathematical interpretations have a lot of philosophical implication that maybe we need to think about more.

42:17 Like when is a preference distribution and a probability difference distribution different and why are they different? Like what is going on when the preferences are not the probabilities?

42:33 Daniel:
Thanks Bleu. Yes. This will take us soon to the tale of Three Piece. Steven first.

42:41 Stephen S:
Yeah, very good points there. When you said Daniel. There about the exact Bayesian on the world bit goes into bit. So it goes into the variational Bayesian. Which in some ways as it starts to hit the Markov blanket and start to give time steps as it starts to go through into the generative model.

43:02 You then go and as was useful from again this empathy with Karl Friston. He talked about the starting point often for active interest is the generative model. How do you get at the generative model? So the general root is that in some ways this exact phase is almost needed in a modeling sense to give you what we think we know the world is when we're setting up our model or our experiment of people doing something, where we're going to see what the results are. So it's like the agent can't know what W is, they can't know what the exact base is bit like with the cat experiment.

43:42 So the cat matrix there, we could arbitrary put one in that we mind of, can say we know as objective observers, it's going to go to the agent and then the agent does something. Okay? And as Bou said, sometimes Zhat, what they do isn't only in response to what's coming in, which is quite often it's not just can I have seen food, can I eat food, as much food as possible, there's this cell. What's the consequence of my actions going forward? Maybe a lot of times we then start to get into this higher dimension stuff where the circle that you put in theorem going into W, there's that red circle on the left which so it goes into the W is what is really of concern the humanities area around what's that about, right?

44:42 And a lot normally the generative model work that is done in Active Inference and is the circle on the right hand side, how do we predict the way beliefs are being updated and what's the way the beliefs because it's normally coming in that direction because you can sort of control you can do an exact base. The one place you could theoretically set your experiment with an exact base is W. It's kind of hard to put exact bays on an agent unless of course it's a robot, potentially. So I think there's something quite interesting there about how much is this? And I think it's a practical instrumental tool, right?

45:25 How much is this about the way that modeling happens and how much and the maths to make that happen and the philosophy to make that and how much then is this broader? And it may be that it gets recapitulated, depends on which parts we simplify or allow to be more complex or want to get a purchase on out of those circles. Maybe you just explain why you put the circles where you put them just to see if I'm getting your rationale. But I think that was kind of useful to put them in. I'm just

highlighting the directedness of these statistical independent this circle of action policy influence unobserved states.

46:12 Daniel:
We've seen it in the partially observable Markov decision process as where that's B w changing through time is b. That's how hidden states change through time. State one, state at time one, state at time two. Then z influences here in this simple, only four nodes. So if you only get four model, you draw the dependency that way.

46:45 Like my action to change the thermostat in the future will change the temperature when we can unpack it a little bit more and move it from this sort of minimal cybernetics or control framing into some of the little bit more built out models we've looked at. That is where policy selection influence b. And so yes, there is enormous concern over how our Active Inference things that we can't directly observe say for by proxies information incoming back to us. And that is not a unique problem to Active Inference. Dean.

47:30 Dean:
I think I'm going to circle back to what Bleu is saying because I think she said on something really critical. The fitness of this, I think is what I won't say was the thing that Karl started on when he took his first nation steps into trying to put something that we can hold on to, something that we can look at philosophically and mathematically. I don't know if he was thinking about fitness at that point when he started down that path, but I think the more we talk about it, the more we realize that as a for example, in a guide use, I think a person who reads Stephen and the other authors work phase two questions. The first one is my use of time, the number of minutes I have to commit to reading the guide before I can then say whether or not certain impediments phase been removed while at the same time. And this is what I think Active Inference does, it also allows us to invert that first accounting of what we are doing with our time inverted from use of time to time of use.

48:50 Like so if I do commit to reading this guide, what's the shelf life of that like? How long am I going to be able to take my takeaways and actually be able to apply them to different concepts? And then there's a fleshing it out part which I think Stevens kind of talking to, which is so when we take all of this information and we embody it, what does that feel like? What does that read out in terms of our behaviors, etc. Our reactions or responses?

49:22 So I think ultimately if we're looking at the wednes of this, we have to start talking about heuristics and Steven specifically spoke about that. He said I wasn't I think I'm paraphrasing him, but I think he said we were concerned about whether starting with simple doesn't also have a cost. We know that it has a benefit because it doesn't overwhelm people. But if we are gain to look at simple rules like heuristics? Does that also have a cost?

49:53 Now, we didn't answer that. I was just re watching the 37 one before we came on today. But I think that's something here that Bleu is now touched on and I think Stephen is teaching on as well. If we're going to put a guide together, when do the rules fall out? Do we assume that they fall out just by picking the guide up?

50:13 Or are they something that the breeder or the user manufactures after having the experience that win? This, I think, is what this Active Inference stuff is touching on. And it's in some cases it levels pretty ready arbitrary. It's hard to tell the win of the heuristic. Do I start with the rule as my prior, my priority, or am I really trying to update and I'm trying to come up with something that reality applies at

some point in the future that I haven't arrived at yet.

50:49 And I know that sounds kind of not answering anything, but even with the statistics, it's hard to figure out what each agent is going to do depending upon what their bias is. Do they want to start with the rule or they want to develop one as they go along? And as the bacillus axillus in 34 Axial's bacterium showed, exact bayes doesn't mean you get it exactly right. It means you're following a process. And with maladaptive prior, even accurate information coming in can result in a adaptive decision making.

51:28 Daniel:
So this is not Penglossian or Pollyannas. Just because there's an approach doesn't mean that it succeeds perfect. Right? Yeah. So Steven Danblue?

51:42 Stephen S:
Yeah. So two points to sort of speak to that. Well, I'll say the second one first because in mind is when we see the modeling, we often see, say we talk about the bacillus or we see the way that modeling happens.
High order agent such as humans tend to find that the w is fixed as a like the cat is either purring or it's meowing, it's in the kitchen, it's an exact or it's in the bedroom. Right?

52:15 So it's a kind of defined, exact, base, kind of context. And then that allows the other parts to kind of still find some very interesting and tractable useful trends right. As it goes through. Now the other way is, okay, how do you get into something which isn't exact DAGs and you tend to see it turn into swarming of voxels phase small Lorenzo tractors or bacillus. So very.

52:50 Very. Very simple agent scenarios with very little degrees of freedom because and it's in a way trying to address that challenge of. Well. You know what. If you don't know if it's in the kitchen or the bedroom.

53:08 It's in the doorway and it's wandering around and the timing between getting sensory information and the action isn't in step. There's a dot. One bleed out and that becomes how much is the temporal. I saw this word from Casper. He's leakage.

53:37 Because there's a leakage out of that sensory I don't want to use the word input, but the statistical dependencies coming in and the statistical dependency is going out. There's a leakage going on which makes the model kind of challenging. Though at some point it becomes, okay, well, it's overwhelming, right? We might philosophically say somehow we're able to do something like that and our biology chaos enable us to overcome that challenge. But to actually put it into a model like the one on the right top right there, it starts to become and in a way, maybe that's where effect comes in, as maybe okay, that may be also true for us.

54:21 That's why we need something like affect to hold together this sort of fuzzier kind of knowing which can't be resolved in Zhat such a solid way. So that's the first piece. The second piece very quickly is you put the red circle that you put next, the X there. So in some ways, while it's sort of inferring W, what we're really doing is we're either inferring the circle there zhat comes in to the X or maybe and that's assuming the arrow that's going into the Bayesian is what's coming out of X or it's coming from X. So that's in a way the edge, isn't it?

55:11 That's the kind of boundary that's being the beliefs. When you say B, the B is about that not

strictly about W. There's a belief distribution on W and X. W is latent modeled unobserved states and X is modeled empirical observed states. Right.

55:36 Daniel:
Okay. Bleu. So just to kind of riff off of what both of you guys were saying, maybe this is tangential, but when you talk about leakage, Stephen, it reminds me of like, the information partitioning that we discussed with Majid Beni and how theorem kind of always has to be some kind of leakage. If you have a complete information partitioning you're actually, like in a vacuum or a bubble, like your existing, there has to be some kind of leakage across the partition all the time. And I've come to realize Zhat, we have to be sharing information with people that are how do we form a markup stock?

56:20 Bleu:
How do the four of us come together and form this live stream today? Right. Like, we're sharing information even though there's a markup blanket that exists between us, and for some of us it's thicker and thinner. Like, Daniel and I will be off, like, doing the same thing at the same time, even separately, just because we work together so much. But this leakage is there.

56:42 And then it also made me think about the maladaptive behavior that Daniel was mentioning. And so when you have this, like, we always wonder what is the cause of this maladaptive behavior? And this is something that we were discussing maybe a couple of weeks ago with Jason. What is the exploration for maladaptive behavior. And it always makes me think about the scale in the situations that are utilitarian.

57:07 Maybe someone sacrifices themselves for they jump in front of a train to stop the train, to save the 300 people that are on the train. And so there's this maladaptive. Decisions do occur, but perhaps it's zhat like a societal scale. Or in a body one piece will die off to save another piece. Even in the brain, like the formation of the glial scar, I think of that essentially it puts a hole in your brain, but it's to protect the rest of the brain from the cell death that's happening in that center hole.

57:43 And so there is this information leakage and even adaptive behavior. Then I think area scale dependent scale friendly.

57:57 Daniel:
Thanks to the dean. And then we'll move to another section. Cool. Yeah. I don't know if we're at an inflection point with this, but I do want to bring this up again.

58:10 Dean:
I think that the leakage speaks to another metaphor that I brought up way too many times last week, which is in the zebra zero, which I think there is a filtering piece to this. I mean, this morning I put the raspberries in the sieve and I assumed the raspberries would stay and the water would pass thought. And there were parts that I didn't need, like I wasn't trying to make raspberry water, I just wanted to eat the raspberries. And I think that if we understand that there's a minimum of two aspects to when we're talking about Active Inference, I think we do ourselves a favor and I think we do ourselves a favor for writing guidebooks about Active Inference and free energy. So I think the guidebook for the guidebook, if there were some pillars that we could put a guidebook on, here would be my questions.

58:58 First of all, there is going to be because we have a Markov blanket, we have a separation that differentiate and that interactions are going to be inherent in however we observe something and then respond to it. The second thing that I would suggest is there's a certain blind spot removal piece to this.

And I mean that in the context of say something like change blindness because of overattending or understanding and where he talked about overfitting or failing to explain that change blindness now becoming a greater awareness availability because we don't necessarily have to lock in prematurely or wait too long. There's kind of a sweet spot that Active Inference is trying to say exists. It's not perfect, but it's better than not having a sweet spot.

59:53 The other thing I would say is if we're ignoring the foraging aspect of this, if we expect that the framework is going to be another frozen meal, then you're going to get the quality of a frozen meal. If you're willing to forge around the perimeter of the store, you're going to come away, switch a whole different experience. It's more time consuming, but in the end it's like learning to fish. It's a whole different way of trying to process those uncertainties. Right.

1:00:22 So I think at the end of the day, what pops out when we decide that we can actually say somebody is using Active Inference, whereas before they weren't. I think what they do is they come up with a new sense of what rules which are being updated, which are being modified, which are being iterated, and sometimes even being extrapolated. We have to really focus on what that means under particular circumstances as we move from place to place. So again, I'm not sure, maybe that's not being fair to the people who wrote a 60 page guide for philosophers, but I think if we're going to look at the foundational things, that area going to be able to tell whether or not we're actually doing and using Active Inference. I would think that at minimum those four things are going to be present, starting with the filtering thing.

1:01:24 Because again, if it's not a minimum of two, I think we over reduce, we put a frame around it, but we don't actually know what's actually a gradient descent and dynamically stable within. That just something to think about if we're going to write guides. Thanks team. Okay, Steven specifically on that and then cell. Go on.

1:01:46 Stephen S:
Yeah, just referring to this idea of screens and bit comes back to the idea of screening off or filtering. I think that the X and the Z here is the question. In this particular context they are talking a lot about screening bit off and it seems to be whereas in other contexts, say Axel constants work, I feel like it's trying to extract as much as possible from the informational potential in an environment. I think that's important. There's a very different I actually used to work as a print broker, so I had to fire up these big presses and it takes 1000 copies to get the magazine actually learning to print properly.

1:02:37 Like the rollers and the blanket has to get inked up and everything. We've got all this weight. Eventually you actually get something that looks good and now it's running. So you've got 1000 wasted copies. Basically you're trying to extract as much as possible from the inked up print head print cylinder.

1:02:53 Right. This is on a big press. Now in that case then you're trying to get as much information basically across into the paper. Now there's other cases, zhat you can imagine where someone's taking a video and there's bright lights going on and you're trying to filter out. Like you say, you got bright light, you're looking at the sun, you've got to filter out to see anything.

1:03:16 In that case you're still trying to get your sensory data in, you still trying to work on the action policies. But both X and Z in a traditional blanket is a dead thing. But how much is X and z, how much is that a living kind of process at certain times that is moving, and you could say it's doing a bit of everything, but how much is it trying to screen out noise and bring in and how much is it trying to

extract from Shannon entropy and stuff like that. So I thought I mentioned that. Yeah, it makes me think of Mike Levin on the phone with somebody, and it's like you're
both trying to pull as much information out of that limited channel, put as much into a limited channel.

1:04:05 Daniel:
And so let's go on to justification links between or among dialectical categories. So we'll do some slide play. We have three types of claims. Dave, I hope I'm using the word appropriately, that theorem are domains of claims mathematical red, empirical Bleu, general, green. Okay, so no commitments, but can somebody just, like, give a specific concise example of where we see one of these cross category statements?

1:05:00 It can be in any direction amongst the three where's a case where somebody uses a mathematical the first part of their sentence is mathematical, and then the second part is empirical or vice versa, where's the situation where the first part of someone's sentence is mathematical and the second part is general. So I'm sure that many have been said even today, but let's try to get a few really specific examples so that people can just learn to identify these kinds of sentences and then we'll be evaluating what they mean. So, Bleu, go for it. So nothing that's been mentioned today, but the Pvalue of zero five demonstrates that whatever my claim is and my experiment is significant, that's something that's all the time you see this statistical justifying the empirical and less stuff. I think we're coming away from the significance of the p value in scientific literature, but you see that a lot.

1:06:03 So where would we put that kind of where would we put statistics? What domains does statistics jump a month? So statistics to me is math. Like, statistics is the sentence that's the field that bridges mathematics and empirical claims like, so when you make the sentence my p value of zero five, p less than zero five demonstrates that whatever my claim is, my empirical claim is significant. So for me, statistics is that bridge between math and empirical claims.

1:06:35 Awesome. Yes, totally agreed. We looked at these two categories of ants, and we saw this one doing it six times, this one did it two times. We did some math on the numbers six and two. You can't do math on the ants.

1:06:52 You do math on the numbers six and two. And from that mathematical claim, we're going to say something about those two categories of ants. So, yes, mathematics going to empirical is a lot like statistics. Okay, what about empirical going back to mathematics? Zhat is a specific natural language expression where somebody begins where the warrant of the rhetoric is empirically driven meaning based upon observation and then the consequence of the argument is mathematical how about because the organism is maintaining body temperature homeostasis empirical it is the case that it is doing predictive processing or Active Inference so here now there area so many ways to even enter here but this would be like from results that's the hallmark of starting in empirical is your starting with something that is almost either trivial or just simply a factor observation about the world so from results to what some sort of statement about now it's interesting about the way that the authors did it here is they have none of the three cases have mathematics in the second position and that's kind of like the Xkcd comic where mathematics is like oh I'm way over here.

1:09:00 I can't hear you the fields arranged by purity meme because mathematics is almost framed as like internally coherent and then information comes out of mathematics but because it's theoretical or abstract there is an internal logic in mathematics called proof and then there's very little need to have something enter mathematics which is why we'll see as we start to flush out this shape stephen yeah as you're doing. That I'm curious what you think about something like gambling say someone is settling

point horses the statistics of the horse gambling and then there's their motivation for gambling so in terms of the empirical you can see okay the behavior is fairly consistent certainly over a type of gambler at horse race the math can be established but then I don't know whether bit goes into the general what's people's motivation for the technology but maybe I'm jumping the gun there but am I on the right lines there in terms of how would you put that into this scenario? Can you restate it with an antecedent and a postseedent just a specific rhetorical nucleus okay. Because X then Y oh. Because there is a group of people at a horse racing track and because we know that these horses have performed in a certain way over previous races we can predict the probability that the horse will win or be told to people to win as being x the motivation for people to make that influence about and the behavioral choices is maybe more general.

1:11:15 Cell get to the general edge because it's very connected to math okay dean no. I was just going to say I like the word results there but I think zhat it's implied is that there were a certain number of observation taken that then move the formalism to something specific is that am I just confirming something or am I putting more in there? Zhat needs to be I had a. Really similar question so when you're talking about going from empirical to math to me like you brought up the idea of like a probability density or like a non equilibrium steady state and like that's immediately what came to my mind. So I don't know if zhat echoes.

1:12:03 Dean:
What Dean just said it does.

1:12:08 Daniel:
Let's get at the distinction between general claims and mathematical claims. So math is sometimes seen as general and when idea are framed mathematically, indeed there's a lot of overlap but the authors do separate it out. It's in section 4.2.2. So what would be like an example of going from a mathematical to a general because math then general or because general claim than mathematics?

1:12:45 Dean:
You can talk about the rate of acceleration due to gravity and then make the general claim that if I go from this height to this height I can expect to bit the group at a certain rate of speed or something I would imagine. Okay, great. I'm going to also pull out just two examples from the paper. So here we go. So we're in 4.2.2 so it's going to be two examples given.

1:13:22 Daniel:
So again we're looking here at math, going to general and then cell, see if we can run it back. So how can mathematical claims justify general claims? Ramsetted Set Al 2018 assert the FEP is a mathematical formulation that explains from first principles the characteristics of biological systems that are able to resist decay and persist over time. First part of the sentence mathematical second part general. It rests on the idea that all biological system instantiate a hierarchy, a hierarchical generative model of the world.

1:14:01 That implication minimizes its entropy by minimizing free energy. I almost see the reflection in that sentence that because of the hierarchical generative model which is a general claim though a formal one, then there is a mathematical implication. So maybe we can put this Ramstead 2018 here okay, and then here's the second or a second example that the author is raised in the paper actual constants contribution to this topical collection rules a mathematical claim to make a general claim on the basis of a numerical example. He argues against the claim that minimizing free energy entails life rather, he believes the converse is true life entails minimizing free energy. We read and loved that paper

and that's very much related to the quote like one ugly fact destroys a beautiful theory or something like that.

1:15:09 Now, is an example mathematical or empirical if it were just on the basis of a family of equations? He argues against the general claim but then again, isn't even the family of Bellman equation an empirical observation from the domain of math? But we'll put it in a section that they had it. So in these cases we're using specific math examples and that was sort of the provocation of 34 and actuals paper which was like I did a math example so it's kind of resting on both the empirical and the mathematical. I did a math example and now I'm going to make a claim about a general topic which is the relationship between free energy, minimization and life.

1:16:04 So that is certainly moving in this direction whereas so because. Math can be abstracted and generalized. There's often similarity here because math rests upon specific examples. Even if the examples are some examples are more general than other examples, it still can be said that they're empirical. Not exactly in the way that cat location measurement is but still it is the case that math produces results.

1:16:43 There can be a result section in the math paper. What about this third edge? What's the relationship between general and empirical? And let's leave math out of it Bleu.

1:17:01 Bleu:
So this is something like I think about like what Dean was saying because acceleration due to gravity is negative 9.8 meters to second squared. When I drop this apple, it will fall to the ground. Like that goes maybe empirical to general.

1:17:24 Daniel:
When I drop the apple.

1:17:28 Because when I drop the apple it falls to the ground. Comma gravity exists in the whole universe.

1:17:40 That was quite a jump. Well, because apples fell in, not down that's flat earth. Because apples fell in, gravity is everywhere.

1:17:56 Okay, that's one example. So then I was thinking of like a sort of ants evolution example. So the general to empirical would be like because of the way that evolution by natural selection is ants optimize task efficiency.

1:18:18 And then the other direction would be like because in my experiment, 30% of the time ants were observed to be doing this selection has been acting on ants.

1:18:33 So these are very interesting because are there some edges that
we rest upon more? Like what if we could just number these edges 12345, six and then annotate people could have different perspectives on it, but we could annotate papers in different areas and okay, if you're just doing one one, one it's like a OneNote paper. From a structural rhetorical perspective, under what situations is that preferable? Not preferable. Are there certain edges that are weak?

1:19:14 Are there pairs of edges like a chord that we want to play together just like the rams did? It was like sort of forwards and backwards. Law of the jungle law the pack from the mathematics to the

general and then instantly a grammatical reflective from the empirical into the mathematical. Okay, Steven, the need.

1:19:42 Stephen S:
One question first. Just ask. Empirical could be seen as zhat exact. Base going in empirical means observed, observed. So the exact parse if you're just taking however you play that out, it actually hasn't been computed beyond observes.

1:20:01 Okay, so reflective. That's true. Okay, that's the first thing. And then general in most senses is what we might call inflated or higher dimension. So we go generally speaking, the models are empirical from observed observation into math into generative model into some general pattern of action selection.

1:20:25 However it could be possible, but generally it's intractable for complex situations to go from general to empirical and then try and get the math out. Which is kind of what Alex is saying. It's like there's a general principle that empirically plays out but good luck finding the math to show it outside of a bacteria.

1:20:56 Daniel:
Okay. Dean so I find it interesting, Dan Neil, that you just to keep the conversation sort of alive as you talked about the edges of those three circles. And I think that the task of being able to find examples of those Bi directionalities, again, goes back to Zhat question of so what are the rules and how fluid are they? And as we're moving from one node, so there's a change, the moving from node to node, we're building that relationship. We're building out these rules.

1:21:38 Dean:
Is that one of the great byproducts of being able to maneuver and manipulate, not getting stuck with only a sense of unidirectionality or oneness? Does this reinforce the idea that if we're going to actually really be able to demonstrate the use of Active Inference, for example, as an instrument or a tool to be able to gain a greater awareness, are we really then talking about how we not just find examples of rules but actually form them?

1:22:21 Because Zhat was the exercise that you just went you just built a whole bunch of rules. I know we've laid them down on the slide as examples. But those relationships now, they're not even bridged, right? They've now dot one sort of a pairing effect.

1:22:47 I'm looking today back to the and then what happens? What I'm looking today for is we got our way to what is theorem now? An awareness, a sense that we didn't have before we went through that effort, the thing that kicks out rules, or is it just examples? What do you think? I'm asking you, Daniel, because you did the most of this work.

1:23:16 Do you see the rules or do we just see the examples?

1:23:23 Daniel:
I just think about how in a nested cognitive model, the outcome of one layer is like the inflow of another layer. So even a rule can be a rule in one layer or application, but yet it's also an example of a rule. Mathematics and general claims tend to be more rulelike. But again, even rules are examples, whereas empirical, it's always the exception that proves the rule. Like, it's the perception is the observation which transfer rules, because if it happened, it had to have occurred.

1:24:07 And so the empirical to me is like examples when you're in this domain and then coherent away from the examples in the scientific, empirical sense pushes us into the rule world. So here this red line is going to be more examples.

1:24:36 And so in that sense, empirical, with the caveat, again, that even rules and generalizations are examples of but in the scientific empirical sense, this is more like an example.

1:24:54 Dean:
Can you hear in your own explanation the sort of justifactory link between example and rule? Do you hear yourself justifying the difference between how we might look at math in general as being different than the empirical? That's all I'm trying to bring out. And again, it makes perfect sense. But I think if we're going to find that somebody use a guide and what is the the result of that?

1:25:32 It's going to be that people have a better sense of what the rules are and what the examples are and what the relationship is between those two things. That would be goodness gracious. I mean, if I'm talking to anybody between the ages of 22 and 62, if we could get there holy mackerel.

1:25:56 Daniel:
Thanks state in terms of opening up. Our understanding of things. Right.

1:26:02 Stephen S:
One thing I think with what you're saying there, Dean, which does become interesting, something Daniel mentioned. When we have multi scale, the actual nature of the rule example actually can shift and as teleologies shift, that I think is kind of revolutionary in a way when we start to think about there's a variation in the nature of what rules are present. So the sort of rules around what it means for me to do something in my environment, my cells individual, I can't play that game, my organs can't play that game individually. Right. So there is this challenge of integrating or maybe this idea of okay, as well as saying what's happening?

1:27:10 Where is something or what temporal and spatial scale does it hold? And I think that may be something that's kind of interesting, is where generally speaking, people go to the racetrack and they behave in certain behaviors at the scale of their part in society and we have empirical data to support that. However, at the biological level it may be something to do with adrenaline rush. You could talk about you could talk about the fact that they just Kappel to have a niche sandwich bar and someone enjoys getting the food right. They don't even like gambling that much, whatever it is, or wearing a funny hat to ask off.

1:28:06 So there's something there zhat could Hohwy do we I wonder that multi scale question because I'm very caught with the idea that you've got Attial constant taking very very small you have this incredibly small world being addressed with active imprints and then we have quite story of, you could say gross examples at scale which ends up revealing a lot at larger scale. But I wonder what you think Daniel, about what happens. And that reflects what Daniel, I think was saying about nested systems and they're sort of informing each other in a way like if I think I'm going to win some money on the races and I better get myself sorted, I might sustain my stomach a bit more so I've got a better glucose level to make a good choice. Right? So suddenly there's two different levels coming into play or just different scale.

1:29:16 I don't think that's confusing things. But I think it does make the modeling question because

Active Inference is ultimately a modeling process which is trying to get at I would say it's trying to either get at the general or to predict an empirical if I'm looking at this diagram, but maybe I'm stating Zhat, right? Where is Active Inference in this? Is this the trace of Active Inference? Is this the map?

1:29:55 Daniel:
And then we play on this territory what is the adjacent possible? So we can ask first, where's Active Inference here and when is it here, and then what next? Dean yeah, this is where I think it's in the relationships and how we decide to parse those relationships. And it seems rather arbitrary, and I think it's one of the reasons why we can always disagree on when the rules are in effect and when they're not in effect. I mean, it's happening up here in Canada.

1:30:26 Dean:
We've got all these rules in place, and then people just decide to pull up big trucks to the order and go, no, we don't like your rule. Right? And so now there's being Canadian, now we have to figure out how we're going to deal with that because we don't have any guns. So I guess we're going to have to disassemble all the trucks or something by Zhang. But the thing is that if you actually look at this, Active Inference is in the relationship.

1:30:54 And I think to Steven's point, if we think that a rule applies without limits, that's the scale free part of it. From a mathematical standpoint, we can find cases where that's true, but then there's a very scale friendly part of it which says, this will doesn't seem to make sense in this specific situation. And that's where Axel came forward. He essentially said, I'm sorry, there was another author we had very recently who agreed and said Bit was Majid. Majid said, look, there's a piece to this that says there's something that's local and proximal and specific, and why are we pretending like that fits the same context as scale free?

1:31:48 So, again, I think I don't see that means that Active Inference and is useless. I think what it means is it can tell us when we can differentiate and when we can integrate that's relational.

1:32:05 Daniel:
So one thing this made me think of is that reading a paper on free energy, free energy principle, Active Inference, and look at the road map. There's no dialectic within a domain. The claims are listed, but it goes immediately to the relationship. So it's like minimum to domains. Okay, now it makes you think about the structure of scientific communication.

1:32:33 So in the results section of the paper cell, so the introduction might have a lot of general and empirical claims selection acts on ants and look at their mandibles, and we know this about niche construction
and look at how they do it. So that is like a very introductory piece. There's not often formalisms in the interoception of the paper. So that sort of Bleu arrow, general and empirical is very introductory in its scope. Then the results section of the paper is like Bleu mentioned it's about like empirical and math.

1:33:06 We saw it do it eleven times and here's the p value. And then we did this and we calculated the model. And so it's like it shouldn't generalize in some senses and then in the discussion there's probably all edges in play, but especially math to general because it's now been generalized beyond the mere empirical. Because we saw a Pvalue in the difference between the nest mates of this type and that type. It does say something about evolution or because there's something happening at an evolution time scale, it's consistent or inconsistent with our mathematical summary statistics.

1:33:44 Yes, that came from empirical, but that edge is more in play. Dean. In simple terms, that's how and when we fit phit the rule. And that almost it does return us to the third P.

1:34:05 So we'll kind of close this section on the two point of four, whatever it was, with the links amongst the dialectical categories. Active Inference as a trans discipline, all of these are often play. And it's almost like if the paper would have just been lists of empirical observations, there be nothing contentious because it wouldn't make any general claims. That would just be called a data set. If it were just general claims, it would be just philosophy.

1:34:42 And that's not to say philosophy is easier or simpler. It's like it doesn't trigger anyone's domain crossing alarm like mathematical biology that does raise people's alarms or generalizing from math. You're saying that because of the free energy minimizing that there's a general imperative for information foraging or relationship between the general and the empirical. Of course, always fraught in empirical science. Okay, you measured in that laboratory study with those undergrads and that stimuli and you're going to say something about aggression.

1:35:20 So it's just very interesting because Active Inference does lay claim or at least lay play to all these areas, that it raises alarms on all sides. But how do we take that alarm pheromone and attention and then just align it with something that's going to be a public good rather than just let it fizzle? Stephen.

1:35:58 Stephen S:
That'S very helpful. And the nature of action and the idea of teleology, soon as that comes in, I don't know if you can avoid being in the general now. Maybe active vision that's just doing a thousand dimensional interpretation of a data set can stick with empirical math. It's either recognizing a photo it's not recognition a photo during some deep computational processes, but action, and particularly then action policy and then teleology.

1:36:36 Would you say that? Would you say the general claims? Where would teleology fit in here?

1:36:53 Daniel:
Teleology is never directly measured. Is that fair to say? So bit can be in green, but it cannot be Bleu. One can say I observed, sorry, Bleu, but I chose the colors for a reason too. One could observe the animal trying to swim to the surface and you can say, well, the teleology is obviously not to drown or something like that, but that's actually structured as because I empirically observe the swimming behavior, I am going to make a claim about the teleology.

1:37:29 So I would say teleology is in a general case, even another spin on this one would be empirical is like X. This is the data that we're actually observing. General is unobserved. You can't observe things that are general. You're only observing what Blake calls the minute particulars W.

1:38:00 What is math?

1:38:05 Math is in the examples that we looked at. It's like the process oh, wait, Active Inference. It's a mathematical process theory. So math is a process or of inference that yes, connects to generalities. And this is not hard and fast.

1:38:28 I hope it's not being interpreted in the most rigorous way, but it does generalize because it has to be like the intermediating blanket. So let's pull this W and X back in here. All right, so here we have

the empirical states here being observed. That's our data. Okay?

1:38:54 And then here's the things that we would like to generalize on. And then this gets to Dean's question about how do you go from this to equations?

1:39:07 And here's math as our sort of blanket in the middle. That's when we actually do, whether it's variational bays or whether it's exact or whether there's some other mathematical approach, it's how we're going to go from these generalized or hypothesized things that we didn't observe. How are we going to connect Zhat domain? And so it's almost like a little boomerang. So there's probably a lot more to explore here, too.

1:39:41 Dean:
Dean, I just like how this come together, because math, as we said, cell, as I mentioned before, I think in the author's mind, the motivation moving forward on the paper was math could be a vehicles, and it can move the process along because it is a process, or it can be an impediment. The other thing that's really interesting here is because it's in the middle, isn't math got a lot of rules in it. Come on. Right. So again, I don't think we're contradicting ourselves.

1:40:14 I just think we're asking, so again, what do we allow to pass through the civ and what do we hold back? And then what assumptions do we make about the sophistication? What's the minimum amount of sophistication around the math process that one must have? Dr. Karl Friston said you must have you must have a good grounded sense of what the math is if you're going to go forward.

1:40:39 Like, he didn't couch his words. He said, if you want this to become a vehicle and not an impediment, you're going to have to set familiar with the math.

1:40:51 Daniel:
And sometimes, oh, the math is not the territory important contribution. And memes for sure, if the debate were about whether territories were maps, it would be the silver bullet to simply claim that the map is not the territory. But it's like right and we want the map so that we can take action and be on our road trip or whatever. So the map is not the territory while it's the conclusion or the second part of the rhetoric for some, especially philosophers who might be inference in what is really out there because the math is not the territory. Comma, then what that's like the dot two of actinF, which is instead of just debating, well, yeah, well, because of homeostasis, what can you really say about teleology?

1:41:47 And because of allostasis, does that contribute to a new understanding of niche construction? They're all important questions, but then where do we go when we put the math is not the territory as our independent rather than our conclusion rhetorically? Steven yeah. When you put here first the math, I totally agree. I was thinking zhat vehicle.

1:42:14 Stephen S:
I was thinking it also takes a exafferent. So, for instance, say I have a million dollars. It gets picked up, it's counted, it's picked up in a car, taken somewhere, and then it counts as a million dollars in between. It's not math, it's just stuff. Right.

1:42:29 But in this process theory, in a way it's the math. It's enabling. And it could be an entropic process, you know, bit could be math in phase, maybe some sort of virtual numbers way or noise way. But the math is the vehicle for the data, right? There is no data, there is no banknote.

1:42:49 Right? There is only a process which enables the general to the empirical. And the empirical in this context is a modeled empirical. In a way, what we're saying is we're going to take most of the models that we see. There's a very simple general idea about behavior, say Ryan Smith's idea about how the heart behaves, how the gut behaves, something about how access consciousness or access awareness is achieved, some general thing.

1:43:22 And then we basically do what we might call a modeled empirical. But you could flip it around the other way and you could have okay, well, in the real world, we could have high dimension empirical. Outside there, what's the general w what's the general x internally, what's the general? Which is what we use as our heuristics, which could be kind of interesting as well, which is maybe more in the action because this is coming in on the century. Right, but I think this is quite helpful.

1:44:01 Would you say that's true. It's a modeled empirical. What we get on them in terms of how we work with it in an Active Inference.

1:44:13 Daniel:
Looking back on it, is there anyone who disagrees that empirical is always as modeled? Like it's kind of funny. Like now I plant to put a little red guy always intervening on this edge, little Bleu guy always talking about specific examples of math and generality. And then the generalization is we use the inApple variance t test. So we generative model connect the empirical and the math.

1:44:52 Dean:
Dean I really didn't want to go theorem here, but I have to. I was way too excited last week when I had a little thought bubble and said, wouldn't bit be cool if Michael sorry, if Stephen Mann and Conor Heins, if we could get them in a room and instead of them talking about what they know, get them to go through this process. Because that's essentially what we want to do is we want to have that little guy pop out as opposed to the one who knows so much in a dense way about their math or so much in a dense way about their philosophical guide. Because that's when the true grasp of what the potential is. And it's not about always having the right answer, it's coming up with the best answer in that moment.

1:45:44 Right? And if we could get more of those kind of situations,
I think people would actually think people actually come away feeling even more confident because that's what this is about. It's about confidence developing. I think one thought on that is like it's possible to stay purely internal to math and that's the internal logic of proofs. It's also possible to state internal to general claims and do philosophy.

1:46:19 Daniel:
Is it possible to stay purely within the realm of empiricism?

1:46:29 In the trivial case? Yes. If you're just aggregating data set and never interpreting them, yes. But empirical in application must either connect to a general question. We observe the answer.

1:46:44 Now we're going to talk about evolution, so that's still qualitative, but it's an edge. And then it rests on math when it's more statistical and on generalities when it's more concept. But it's just sort of interesting that the internal logic of empiricism is basically just data integrity, but it's like pre interpretation, which is perfect for it being x, whereas there's a whole guild structure and discipline around internal mathematics and internal generalizations and philosophy. And so it's like and I also really agree with that, having them I thought you were going to say just get them in the same room and then just talk about food or music or something like that. No, but I know what you mean.

1:47:36 Have them and just like we're all learning by doing in this space. And to say that this is a lifelong journey would just be a total understatement. It's broader and deeper than that. So how do we recognize the complexity of this arrangement as well as the adjacent possibles other ways that it could have been made, other end states that we could have reached, bringing in any number of fourth points to make a tetrahedral, any other number of orders of paths that we could phase done to reach this point. Like if we had started with these little dots and then later added the arrows.

1:48:15 And how did we start this whole thing with examples of each edge? So getting to the super like fractal multiscale level and we didn't even add any formalisms or mathematics here but we could have done some pseudo code or some pseudo equations to really start to link this and to lean more on our mathematical leg and that's the whole thing that you just said about confidence Dean which is like this is the space that we're going to be bouncing around and you can ignore statistics and you can just have an emotional response to p values and stuff like that but you will need that as part of the journey we can't just be like the post office vehicles that don't make left turns we have to make all of our tools available at the team level and then trust that with like distributed recognition model with guides and wayfinders and peer facilitation that we can make it work despite how fast this area is so yes. Steven. As we go for our final commentary yeah. I think you made a good point there with that green arrow just one last thing with the green arrow you put there.

1:49:34 Stephen S:
Could that be more implementable like? It becomes more implementable as you go that direction away from the math with a mixture of genuine and empirical just curious. Yeah, the arrows again it's open to interpretation otherwise it could have been done I was thinking what links up math and empirical? They're both more numerical, that's the bottom edge okay then what makes math in general similar? They're less ExampleLike and then what is the similarity between empirical and general?

1:50:16 Daniel:
So what is not just pointing what's the arrow that doesn't point to general but what's the arrow that points between general and empirical and what distinguishes mathematics from general empirical? It might be its formalism but general. Is it but I'm thinking representation or maybe this does get into teleology it shows you more like the empiricals what's actually happened this is an example the accountant said to us once and it always stuck in my mind is I said this before what is an organization doing? What's bit about he said don't tell me a mission, don't tell me your vision, show me a budget, show me what you're doing or show me where you spend your time so in a way it's like that what's the empirical as well as the go to the general to show me? Well that gives an idea then of something that can be done as opposed to words or even a mathematical or words can be like a mathematical formula in many ways to help tell people what you want them to think zhat maybe not what is going on?

1:51:28 Stephen S:
So I'm like those three arrows, I. Think it's very useful any final comments in the last 1 minute, Dean? And then Bleu real quickly I think that a lot of times conferences, people go and theory want to talk about what they know but I think that this examples today was an example of where you come in not necessarily knowing but discovering I think it's another fine example of what we're talking about when we're talking about Active Inference. If I caught Stephen Mann and Conor in the same room, the place that I would want to begin is what don't you know? How would you guys attack this from not your strength preferences, probabilities and fit, but from what you don't know but is still in the room.

1:52:17 Dean:

And I think that's very complexity to the more traditional conference way of disseminating information. There's my word for today. And then even socially at the conference, people connect with the people who they do know, and that's the little click network instead of connecting with people who we don't know. And so it also ties to, hopefully, some of our values, too. So Bleu.

1:52:42 Daniel:
Any last thoughts? I've just thought of complexity science and the interdisciplinarity and the real value that goes into colarning or working outside of your comfort zone, because really, that's where the growth happens. So I like those idea a lot. Yes, working with people, you know, can have amazing Pragmatic utility, and it must be balanced with the epistemic and switch, expanding our horizons and perspectives as well. So, yeah, totally agreed.

1:53:15 Well, another fun one. Can't say we prepare too much, but I think in the end it went just fine. So thank you all for joining and for participating. And we'll see.