ActInf Livestream #035 ~ “A tale of two architectures free energy, its models, and modularity”

Discussion of the 2021 paper by Majid D. Beni, “A tale of two architectures free energy, its models, and modularity”
https://pubmed.ncbi.nlm.nih.gov/34942581/

Presented by Active Inference Institute in 2022

Session 035.0. January 4, 2022

https://www.youtube.com/watch?v=e-Ck8sxCME0

An introduction for some of the ideas in the paper.

SESSION SPEAKERS

Daniel Ari Friedman, Dean Tickles, Bleu Knight

CONTENTS

TRANSCRIPT

00:03 DANIEL ARI FRIEDMAN:
Welcome Bleu. I'm about to play the theme song.

00:32 Hello everyone. Welcome to actinflab live. Stream number 35. It is January 4, 2022, so also Happy New Year to everyone. Welcome to the act inflab.

00:48 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 recorded and an archived livestream, so please provide us with feedback so that we can improve our work. All backgrounds and perspectives are welcome on these live streams and we'll be following good video etiquette. If you go to Activeinference.org, you can find out more about how to contribute or get involved, because anyone who is curious and wants to learn more will have a niche for you and you will surely learn and create all kinds of awesome affordances.

01:30 So if you're curious or you want to learn by doing, please come get involved with Active Lab today in Active Livestream number 35.0. We are going to be learning and discussing this paper, a Tale of Two Architectures Free Energy, its Models and Modularity by Majid Benny in December 2021, but kind of published in 22. And just like all the other dot zeros, the video we're about to do is just an introduction and a discussion. It's not a review or a final word. And in fact, we're very much looking forward to the two upcoming weeks when Majid may join us and hopefully many of you will join us.

02:16 And we're just going to have a good time. Talk about the paper, what have we learned from it and what are the implications? Today, we're going to be more focused on the aims and claims, the abstract, the roadmap, the background, the keywords, and there aren't any figures or formalisms, but we'll go through some of the key arguments, which are very provocative and very salient. So if you want to get involved, just get in touch and we will let you know how to participate. Let's begin with a little bit of an

introduction and a warm up, so feel free to say hello and maybe just one thing that made you excited to discuss this paper.

02:53 So, I'm Daniel, I'm a researcher in California, and I was excited to read philosophical work by Benny, who always writes very interesting things and just understand how architectures of physical systems and their functional descriptions are related to the FEP. Dean.

03:13 DEAN TICKLES:
Thanks, Daniel. I'm Dean. I'm here in Calgary.
It's really, really cold and snowy, but that's not why we're here. My real question was, so what do we do about this seeming filly or attraction to the ability to categorize? And so the question is, do we model up? And yeah, so reading the paper, I kind of tried to figure out the answer to that. I'll pass it down to Bleu.

03:42 BLEU KNIGHT:
So I like this paper from the perspective of multiscale dimensionality and also modularity like modules at different dimensions. The scale free aspect of the Markov blanket and or the not scale free aspect of Markov blanket. And anyway, I thought it was just really neat and a cool way to fit the pieces together. Excellent. So we have some slide with things that we want to discuss in the dot one and the dot two and beyond.

04:14 Daniel:
So at any point feel free to add information there and we'll be writing things there. So we're not going to get to it all, we're not going to make this eleven hour video. We'll get things down to discuss in 35 one and two. But we can lead in with the big question, a big question which is how do we think about modularity of different kinds, like functional, effective and anatomical, which we'll be discussing later in active inference and free energy principle? And why does that matter?

04:49 Why does it matter how we think about modularity of different kinds? What does it mean? Here on this slide are some images related to just different uses of modularity, just modules like Lego bricks. Other times modularity can refer to like part of a network that's more densely connected, like a click. Other times modularity doesn't refer to hot swap ability, but rather to a larger structure that's composed of smaller modules, whether they're the same or different.

05:22 It's often applied to mathematical systems or biological systems. So there's so many aspects of modularity and today we're going to be exploring what are those aspects of modularity and why does it matter for the free energy principle? Bleu or dean like. Any thoughts on the general modularity question?

05:44 Dean:
I got a quick question. So for me, when we see these sort of images that we externalize in artifacts and that sort of thing, when I started getting to the paper, the real problem for the modularity argument is what does localize mean when we're talking about fMRI representation as the tool? Does a bump and electrochemical impulse mean a clearly defined border? I don't think so. Of course not.

06:14 Where one bump ends and another begins all inside the same energy field might be captured through fMRI imaging. And is that misleading because there's no moment of stasis because the magnets inside our heads keep worn constantly. So that was again another question that I sort of tried to carry on through as I was reading what the author wrote out. Yeah, where are we talking about

modules? Where are we modularizing?

06:44 Daniel:
And does that map onto potentially realism and instrumentalism? Any big setting ideas? Bleu or we can continue to aims. Alright, so the paper that we're discussing is, by Majid Benny, the tale of two architectures free energy, its models and modularity. And it's in the paper, Consciousness and Cognition, just to go through some of the key aims and claims and then feel free to add a comment.

07:13 So the paper presents a modelbased defense of the partial functional informational segregation of cognition in the context of predictive architecture. More specifically to defend a modularity thesis, the paper computes two counter arguments that lie at the center of Hipolito and Kirchhoff's recent confutation of the modularity thesis. To confute is like to refute, the main insight of the paper is that Hipolito and Kirchhoff's counterarguments miss the mark because they dismiss a few rudimentary facts about the modelbased nature of dynamical causal models and Markov blankets.

07:56 So that's why we kind of led in with the big question about modularity. Why does it matter? Because we're kind of down the road a little bit like, okay, modularity matters. It matters how we think about and analyze and design modular systems and then how does it apply to FEP? And Hipolito and Kirchhoff make a computation of the modularity thesis, which we can look at soon.

08:20 And then Benny is firing back with this current paper. So that situates us like in the biggest scope of thinking about modularity H and K 2019, and here we are with MDB 2021. So can I add to that? Daniel? Yeah.

08:39 Dean:
So we didn't put encapsulation in here, but I know we're going to talk about that a bit. But in order to be able to make sure that we don't mix things up, we have to understand that encapsulation is a separation of what matters or what we consider to be a signal from the noise. And I always think back to Nate Silver when I try to compare those two things. So it's a momentary on offer, it's a momentary in out. Not that there's a walled off section per se in the brain.

09:11 Like we can diagram out or represent as an artifact. fMRI images, however, might coercive into thinking that that's what's happening, that there's actually a walled off section when that isn't actually the case. To avoid the cognitive overload, there are breakthrough mechanisms in our mind. We don't have to tell our pancreas or basic Anglia what to do, which then assists us in our ability to take the external states like these slides in. And I think that's what Benny was trying to point to, although he didn't probably go into that explanation the way that I just did.

09:47 But I'm kind of in defense of this author. So I'm starting off right now. I'm in his corner. I'm ready to tag up and climb in the ring. So just to kind of piggyback onto that, like when you're talking about encapsulating, it's really talking about drawing a boundary around something.

10:06 Bleu:
And isn't the Markov blanket, isn't that the ability to draw a boundary around something? Right? So I don't know, like this encapsulating, Markov blanketing, boundary drawing, like, all of those are conflated in my mind and I don't know if there's like a separate way to tease them all apart or if I have correctly grouped them. Great. Onwards.

10:30 Daniel:

I'll read the first two and then Bleu for the second two. The paper presents a modelbased defense of the partial functional informational segregation of cognition in the context of the predictive architecture. The paper argues that the model relativeness of modularity does not need to undermine its tenability. In fact, it holds that using models is indispensable to scientific practice and it builds its argument about the indispensability of modularity to predictive architecture on the indispensability of scientific models. More specifically, to defend the modularity thesis, the paper computes two counterarguments that lie at the center of Hipolito and Kirchhoff's 2019 recent computation of the modularity thesis.

11:17 Bleu:
The main insight of the paper is that Hipolito and Kirchhoff's counterarguments missed the mark because they dismissed a few rudimentary facts about the model based nature of dynamical Kaza models and Markov blankets. Great. So nice philosophy. Abstract. Here is the roadmap where we are going.

11:40 Daniel:
And so this has a fun roadmap. There are nine sections. There's the introduction and then there are eight sections with or dare I say, eight modules that have kind of interesting
names that we'll be looking into. And there are not any figures or formalisms, but the sections are here. Maybe Dean will rejoin.

12:09 And welcome back, Dean.

12:15 I need an Ethernet cable from my heart to yours. The keywords are free energy principle, modelbased science, modularity and then there's Dag directed Acyclic graphs and then DCM, which is going to have two different unpackings as directed cyclic models and as dynamical causal models. And we're going to go through these keywords kind of as they appear in the paper. We're not going to have a separate section. So let's go right into the introduction section of the paper where we find somewhat of an epistemic preamble.

12:59 So not to read the whole thing, but Benny belongs to the clan of philosophers with Carnap and Kuhn who concede that the choice of theoretical frameworks is not completely arbitrary because some pragmatics affect the choice of theories. So, okay, we have dispensed with the naive postmodernist perspective and more generally Benny identifies as a naturalized metaphysician in the sense of Ladymen and Ross, in that metaphysics is worthwhile when it is informed by our best scientific theories of the field. So it's kind of just like a classy coinforming process between science and metaphysics. And it is drawing on this work by Ladyman and Ross, everything must go metaphysics naturalized. And then just to look at the chapter titles, because it's not a book that I was very familiar with, they're defending science, they're defending a scientific realism and a structuralism.

14:06 So maybe we're not going to be in touch with the ultimate reality, but at least we can be in touch with something that's constructively, empirical and scientifically real. They talk about the unity of science consilience like EO wilson and about causation in a world that's structural but also complex. And so that's sort of the preamble where Benny characterizes his own stance and kind of gives us background that is quite personal in some ways but then will lead into our understanding about the paper and the contribution. So anything to add on that? All I would try to quantify here is that he's not starting from a position of did you see that?

14:50 Dean:
He's basically starting from a position of did you see what I see? He holds that as being valuable. Great.

15:01 Daniel:
That takes us to modelbased science. So as we saw in the chapters of Ladymann and Ross, scientists use models. It's kind of like saying we use maps on territories. And there's so many kinds of models. A few that we've seen are for example, a graphical visualization of a Bayesian statistical model.

15:28 And one example of that is like this partially observable Markov decision process that we often look at. And what do models do? Well that's quite a big topic, but they representation hypotheses as well as useful models of conceptual or empirical systems. And so there's many, many kinds of models and some of them can be reflected graphically. And in that sentence graphical is referring to visual like a computer graphic, but also graphical like a graphical network.

16:03 And so we're going to be talking about the visual aspects of graphs, but this isn't a study in aesthetics. This is going to be talking about the topology of graphs in their network sense. But modelbased science is just the kind of pragmatic perspective that scientists use models implicitly and explicitly and there are certain things that we can say about those models. Anything that either of you would add on model based science, I'd want to know. Who disagrees?

16:36 Who doesn't think that scientists are using models like is this just a total meaningless claim or are there controversies related to this? Okay, so let's look at a few different types of models, specifically these graphical models that can be represented by networks. So one kind of special graphical model is called a directed acyclic graph or a Dag. And so Dags, as their name would have it, do not have cycles amongst variables. So nodes are variables and edges are directed influences and there are no cycles in Dags.

17:21 And so it turns out that computing Dags, it's relatively efficient and it has known algorithms. So here is an image of a Dag that I got from a 2012 paper in Ecology. And so the parameters are defined here and you can look for more details, but just visually. These are different modules of the model. There's like this underlying process model.

17:48 There's the individual covariate model, there's an observation model, whatever those things are. But one can imagine that you can like start at the parts that don't have any parents and then kind of drip coffee your way to N and Y which are like the ultimate grandchildren nodes and then N and Y don't feedback to change the other upstream parameters. So Dags are not all of this exact shape or type, but what makes them in a category is that they don't have cycles in the way that the variables are influencing each other that makes them easy to compute and relatively straightforward. We can contrast that with directed cyclic models. So we're still talking about graphical models here.

18:44 Directed cyclic models or DCM have causal loops in the graphical models and so this can make certain kinds of computation more difficult. I'm sure people can think about different ways that that might happen. The direction of the edges determines the influence of one random variable on another. So if it doesn't have cycles, it's a Dag. And inference on those Dags may be performed exactly using algorithms such as belief propagation or variable elimination.

19:17 Like you can kind of collapse a subtree into a simpler system, but with cycles it's a little bit more complex. So that's the difference between the Dag and the DCM directed cyclic model. But then there's going to be another DCM coming up later. Any comments there?

19:38 Dean:

Do you think that the looping can be get kind of a spiraling, kind of an accumulation effect that the Dag model, which with its narrowing and narrowing and sort of illumination focus? Well, Benny talks about the fact that they're actually complementary, but do you actually think they're complementary as well? I think that they exhaustively describe the landscape of graphical models because either it has a cycle or it doesn't. But it's quite literally the difference between dropping a coin in a little machine that just dribbles down and then playing pinball where you can have all kinds of feedback. So I think they're mutually exhaustive, but that may be sort of a deflationary stance because they are defined as contrary to each other.

20:32 Daniel:
We're not going to go too into detail here, but sometimes you want to use a model that is a cyclic, even for a cyclic system, for example, within one time step, it might be a heuristic approximation to make it a Dag model directed a cyclic model rather than a cyclic model. So we're talking about our statistical models here, not the topology of how things are connected in the real world. But I just thought it was very interesting to talk about Bayesian Networks. And often Bayesian networks are framed as only Dags. So the standard definition, according to these authors, the standard definition of Bayesian Networks is usually one directional acyclicdirected graphs.

21:22 In higher dimension systems, further probabilistic relations can be recovered from network cyclic properties and the joint probability of all variables. And this paper shows like for a two system where there's just a kind of back and forth between these two x and Y variables here's x, Y and Z in a three way loop and then here's a four way loop and then they also look at N order loops so it can generalize. So what was once only imagined is now proved. In other words, let's not get too confident about what can or can't be done with one type of model family or the other, because it's just one clever paper away for there to be an approximation or to be an exact solution. Now we turn to the other sense of DCM and this is dynamical causal models.

22:20 And so these DCM can have graphical structure that also is directed a cyclic graph, but it's a different usage of the term. And so DCM here we could point to many resources like Fristen et al. The 2007 Statistical Parametric Mapping textbook or a later paper of Friston et al. On network discovery with DCM. And so I thought that 2011 paper was a little bit more relevant because it's about specifically inferring or discovering the functional architecture of distributed systems using dynamic causal modeling.

23:02 What does this technique do? It uses Bayesian model selection. So comparison of the relative adequacy and complexity of different Bayesian models to identify the sparsity structure, which is where there are edges or not, or where there aren't, which is the same thing as where they are in a graph. That is best explaining in observed time series the implicit adjacency matrix that's that sparsity structure specifies the form of the network e g, cyclic or asyclic. And then later on we see unlike conventional approaches to network discovery, DCM permits the analysis of directed and cyclic graphs.

23:41 So DCM is an approach for looking at a time series that's the dynamic part through a time and then looking at how variables statistically cause each other. And so a statistical cause is like when one thing happens and then at some later time point there's another thing happening that's a statistical causal model. Like Granger Causality, we're talking about our model. So if Bitcoin price goes up and then later oil price goes up across the whole time series. So there would be a directed causal edge, there might be a bidirectional causal edge or onedirectional causal edge.

24:20 It doesn't mean that in the real world one going up caused
the other. It's just talking about our time series data. So that's dynamic causal modeling and it can be applied to neuroimaging data. Bleu I have a quick question here. So I get the time series that that makes it dynamic.

24:37 Bleu:
But I also thought you could have functional studies that also fall into the category of dynamic causal modeling. Like gene knockouts, right? Like you knock out a gene, not necessarily a time variation, but like a variation in the graph itself. And so you knock out a gene and then isn't that also dynamical causal modeling? Or that's something different.

24:57 Daniel:
One could have like the nodes be gene expression through time and then test how perturbations or counterfactual network architectures would result in different expressions through time. But can you take the time out of it and have it still be a dynamic model? I guess it's just snapshots, right? So it's not time series but like gene series. I don't know, like knocking out the genes in the series to make it a dynamic model.

25:30 If it were just a single time slot slice, then it's a little bit unclear what the edges would reflect because cause is like effect through time in the statistical sense. So if it were just like I have, like there's 50 people here and 20 people here and ten people here, it's hard to say where is there a causal edge? Whereas if all three were changing, then one could draw these causal edges. Okay, now we turn under the scope of the big question about modularity to specifically modularity and the free energy principle, FEP. Okay, so this is the big topic and kind of the entree that Benny is bringing to us to discuss and it's highlighting a really important issue, which is the conceptual compatibility of modularity with the free energy principle.

26:28 And it's a speculation that this conceptual point may well become significant in the course of scientific development of the FEP. So this is like a philosopher engaging in a scientific discussion because there actually is a lot on the table if we get modularity right or wrong. So what is the relationship between FEP and modularity? Is it compatible? Is it necessary?

26:56 Sufficient? Incompatible? Like if we have modularity, do we get FEP right? That's sufficient. Do we need modularity for the FEP necessity?

27:08 If we have it, can we not get the FEP in compatibility? Are we talking about the modularity of our world carving up nature at the joints or of our scientific statistical models? Instrumentalism carving up our models at the joints that we designed? And then how does our stance or our perspective on this topic of modularity and the FEP influence our generative model? How we think and act, whether we're the ones collaborating and writing scientific papers or not.

27:40 And then just to add one more note, despite the great unifying scope, FEP has been criticized on account of not discussing the functional mechanisms of the brain. So the unifying scope is kind of like topdown that's the rampstead at all 2018 all of space and time under the FEP envelope. That's the top down description. And then the functional mechanisms are like those minute particulars that's the bottom up components that build the system and that sort of meets in the middle with the real world systems that people are always discussing. So we're talking about how modularity works with the FEP or not.

28:26 Any thoughts? Bleu or Dean?

28:31 Dean:
Well, the only thing I would add is that you can be strictly top down or you can actually, as Benny would point out, keep an open mind, which means that you've got some movement for both top down and bottom up. So we'll probably get into that more in the zero one than zero two. Yes, exactly.

28:54 Daniel:
We're now going to go to some classic citations. So Benny writes to address this problem of modularity and FEP, FEP theorists may want to provide finer details about the functional mechanisms that enable FEP. So that's how we're going to make a comeback to Colombo at all 2021. Colombo and write 2016 is by providing finer detail in addition to reinvigorating its unificatory scope. Unifying scope.

29:26 Maybe that would be in line with Fristen's preceding remarks that, despite its roughness FEP, may be developed to provide a guide to brain functions. So we're going to do both. We're going to keep the big scope and we're going to provide details. So let's look at some of those details. This is also going to provide a really good introduction to the difference between the functional and effective connectivity.

29:50 And connectivity here is referring to statistical measurements coming from brain regions because anatomical connectivity is just are the pieces physically connected? The knee bones connected to the leg bone? That kind of descriptive anatomical connectedness. First in 1994 functional and effective connectivity in neuroimaging a synthesis so back when we were younger, weren't we? The paper reviews the basic distinction between functional and effective connectivity in neuroimaging, going over to the origins and definitions.

30:28 Functional connectivity is defined as the temporal correlations between spatially remote neurophysiological events. So that's not the only way to say it in English or any other language. But we're not talking about a philosophical sense of function like what does it mean or what is it teleology. We're talking about statistical variation in measurements. This definition is operational very cool and provides a simple characterization of functional interactions.

31:02 The alternative is to explicitly refer to effective connectivity, I e. The influence that one neuronal system exerts over another. So temporal correlation is things that are like, they could be uncorrelated in the micro, but then they're both going up together. That would have functional connectivity, whereas effective connectivity would be looking at how changes in one at the next time step influence changes in the other. And so those could be like going in different directions at the macro, but they could have effective connectivity because they influence each other statistically.

31:46 Let's stay with this Friston 94 theme, but we're not going to go through the whole thing. This is just to show like what was being discussed and explored and characterized about 30 years ago. So keep that in mind. We have a long pheromone trail to catch up with Carl on. This is back in 1994.

32:08 This is 94. They had models back then. Well, they were made of wood. But yes, this is a statistical parametric map, hashtag SPM projected onto a brain. And on this map of the images, take it through time of a brain that were fMRI.

32:32 In this case, one can take that data object and find the eigenvalues. And there are mathematical

relationships between functional and effective connectivity. Not going to go into it, but it's an awesome topic, explored here and in several earlier papers and in the 2007 SPM textbook and in later papers. What was able to be said even way back then? Well, this is one of the figures.

33:04 These are looking at the loadings on different vectors. So it's a spatial mode that reflects an eigenvector. So it's kind of like a vector through space and time activity that explains a large proportion of variance in the data. And the first vector, that's the top one is clearly related to the difference between word generation, even numbered conditions and word shadowing, odd numbers scans. So this was an experimental paradigm where the person was being asked to do two different things alternating generate a word and then shadow a word, like I guess repeat a word that was already said.

33:48 And then this vector which had this activation pattern on the right in the brain was negatively correlated with the odds and evenly positively correlated with the even. So it's a plausible mechanistic statement about the differences in the activated neuroanatomy. Doesn't mean it's simple to interpret, but it's a vector whose expression is correlated with something in the experimental design. Like if you did a doubleblind study and these people got the drug and these people got a different drug, the correlation between them would be ascribed to the difference that you as the experimenter imposed. Whereas here's an example of another vector that declines throughout the entire experiments and so that might reflect, for example, attention dropping off through time.

34:49 And so that's a lot of neuroimaging then. And now looking into these summarized statistical representations of activity patterns through time and also for later just it's cool to look at some of these citations like the Edelman citations, Tonya and Sports 92. These are really classic citations. So there we were 94, and then this is a dream of the future from 94. So here's Zargami and Friston in 2020 again talking about effective connectivity, biologically grounded models like dynamic causal modeling and dynamical systems theory.

35:40 So improving and iterating on those basic ideas. And then also what does it look like to apply it and what kinds of conclusions and statements do scientists make when just applying these methods. So for example, this paper was in 2019 and it is called Dynamic Causal Modeling of effective connectivity should sound familiar during Anger Experience in Healthy Young Men seven Tesla MRI Imaging study. And so you can read the abstract, but they find that viewing certain kinds of films leads to activation of certain brain regions. Dot, dot, dot, dot dot.

36:22 We propose a model of effective connectivity associated with the anger experience based upon dynamic causal modeling. The findings have implications for psychiatric disorders. So that's what people do. They put people into scanners, they take measurements of the hemodynamics of the brain and then make
a statistical model of it. And the edges that exist across all subjects, or only in the ones who have this diagnosis, or only in these experimental conditions, those edges are interpreted in a certain way.

36:57 That's what's on the table while we're discussing all these techniques. Any comments on Friday 94 or we'll go to the other classic just the. Effective connectivity is what I was thinking of. Like in the gene network. Like, how are they effectively connected?

37:13 Bleu:
So it makes sense now. Yes. Another classic, but a more recent one is 2009 1st in this paper, again, single author paper, the Free Energy Principle a Rough Guide to the Brain. So now that's how long ago? 13 years ago.

37:37 Daniel:
The Free Energy Principle might provide a comprehensive account of how we represent the world and come to sample it adaptively through action. By moving our little eyes around, the FEP provides a mathematical specification of what the brain is doing. Now, that starts to sound like realism, right? What the brain is doing, not a functional description of the models we make about the brain. It is suppressing free energy if it uses gradient descent.

38:08 And so the box with the questions for future research are really still key. What optimization schemes does the brain use? These are like still important questions. And then also the domains of application. It's just always good to see.

38:32 What was the FEP's description and scope 13 years ago? Some of the images we've even seen, again and again with sometimes some variants, but these are like images that we see commonly. We talk about action to minimize surprise and perception to optimize the bound. So this is like the predictive processing element and this is like the control theory element. We talk about the topology of perception, cognition, and action.

39:08 So suffice to say that there are equations, figures, and it's another great paper on the long road towards the FEP. Any comments on 2009 paper? All right, Bleu, would you like to describe modularity? Sure. So I just wanted to explicitly define it because we talked about it a little bit in the abstract and we're going to talk about it a lot more.

39:37 Bleu:
But in the paper, the author defined modularity as information encapsulation, which Dean mentioned earlier. And he says informational encapsulation holds that when engaged in information processing, the subsystems do not have access to information processing in other compartments. And information processing within each subsystem is constrained within the computational mechanisms of that subsystem. And so the modules are then defined by information segregation. And it's interesting to compare modularity, like encapsulating information in a module versus defining individuality, which but both, like Mike Levin in The Computational Boundary of a Selfpaper that we did last summer, and then David Krakauer in his 2020 Theory about the Information Theory of Individuality.

40:30 Both of those authors talk about information sharing, like information sharing, like, with cells to form a tissue, for example, in like, Levin's work, and then in the information theory of individuality paper, like up and down across different levels so that you can define individuality at any given level. But it talks about how information is shared with this bi directional causation in that paper. And so I think it's interesting to compare this idea of informational encapsulation in a module with these definitions of biological individuals. Very cool. Like, is modularity the same thing as individuality?

41:09 Daniel:
How about continue describing maybe in this discussion on intransitivity? Well, so I had to look this up. So I went into the paper. I just wanted somebody to just define what does this intransitivity mean? And so the author says the general insight is based on the intransitivity of the passage of prediction errors between levels whose information can affect one another only in cases of uncertainty and noise.

41:37 Bleu:
So I feel like that this is like intransitivity of information between the modules, but it was just not clear enough for me. So then I tried to look up like, what is intransitivity? What is this intransitivity theory?

And I came across this really cool paper, which is 2015 and entropy intransitivity in theory and the real world. And I think it's really different than what we're talking about here.

42:01 But it talks about like, intransitivity in terms of preferences. And it said the choice between transitive, which are transitive, which are absolute, and intransitive which are relativistic models depends on the nature of the processes that these models are expected to reproduce. Many people, however, have a psychological difficulties in accepting a relativistic approach, expecting an absolute scale of judgment from bad to good which can be suitable in some cases but excessively simplistic in others. And they gave the idea of intransitivity in game theory. And so, like, an intransitive game is just rock, paper, scissors which obviously like your choice there's no, it's not.

42:39 Rock is always good, paper is always good, tails never fails. It's always relative to what the other people are choosing in this game. And then they really go into multidimensionality and intransitivity. So he says in the paper, coarsening, which is like corresponding in multi dimensional cases, become strictly intransitive and the cases without strict intransitivity are degenerate. Either dimensions are redundant or coarsening is performed after merging the fractional variables into the overall utility instead of independent coarsening for all or some of the criteria.

43:14 From a philosophical perspective, this statement can be presented as a continuum argument for intransitivity. Small alterations are commonly overlooked for secondary parameters that can be accumulated into critical differences. And so I just thought that this was cool because it talks about like, philosophy and some things that we're talking about and relative or like realist versus instrumentalist, but it's completely unrelated. And I just wonder is it completely unrelated or can we go back and then link intransitivity full circle into what we're discussing here today? So I put this in here because I thought it was a cool paper.

43:46 And in my search for intransitivity, that's what I ran into. Awesome. Putting a number on something often makes it seem like whatever you're putting the number on, they are transitive. If everybody gets a score out of 100, then there's a natural order. Or if we're ranking policies according to their expected free energy, then there might be some ordering of policies according to which ones are best minimizing free energy and I think this idea of intransitivity within the graphical model, what kinds of information that are being passed and what does it mean?

44:21 Daniel:
And then just more broadly, like you brought up with the game theory, it's very interesting.

44:27 Alright, let us continue almost finishing the first section and get to modularity FEP and the target of the paper, which is the Hipolito and Kirchhoff paper. So without intending to map the course of the evolution of the FEP like we will, Bleu, I will just remark that the assumption of modularity has been fruitful in the study of brain functions. And so keeping an open mind about that assumption could be fruitful for the FEP too. Some significant critiques such as Hipolito and Kirchhoff notwithstanding. If you want to read more, definitely check out this paper from late 2019 by Ines and Michael.

45:09 And they are also, as well as any of you, welcome to come on and discuss this paper. That could be really cool to kind of embody and enact the paper and are we on the same page or what are our perspectives? Even if we are on the same page and this paper is engaging in the discussion of the relationship between modules and modularity. The main goal of the paper is not to defy Hipolito and Kirchhoff's attack completely. The notion of modularity that Benny will defend is weaker than the notion that they attack.

45:41 So what senses or types of modularity are we dealing with? What are the stronger and weaker claims? And we'll look at their definition on the next slide. The main point of the discussion is that according following Hipolito Kirchhoff, the modest definition of modularity is neither insignificant nor indispensable. So that made me ask are we seeing a trend towards instrumentalism bottomup weak claims like the entailment exploration of 34 and deflationary models and moves away from naive or realist strong claims?

46:25 And so that just totally points to the role of philosophy in an ongoing scientific domain because things like strong and weak emergence or entailment relationships and these discussions on modularity, they really matter for how science is done and how it's interpreted. So it's just really cool to be seeing that happen in a new way. Again, we're not going to go into the whole argument of Hipolito and Kershaw check out the paper, but they are going to consider the three most well articulated, which is funny because that means well said, but also well jointed arguments for the view that modularity and predictive processing work well together. So predictive processing here is also referring to kind of that component of active inference. And they're going to argue that all three of these arguments for modularity come up short, albeit for different reasons.

47:23 So they kind of do like a steel person where they give the strongest argument for that tack and then they've refuted it. And the three arguments they discuss are the Epistemic Bayesian courtroom argument, which is just the idea that courtrooms are modular and cognition is kind of like a courtroom, like the eye is like a witness
and then there's like another witness thereof. And so if that's modular then shouldn't predictive cognitive architectures be modular? B the intransitivity argument which is that the causal influences across hierarchical levels are instantiating mechanisms that implement causal bayesian networks and they basically say that is pitching predictive processing in terms of the Dag as opposed to cyclic models. And see the Markov blanket argument, the notion that a Markov blanket grounds the idea that predictive processing exists in modularity and so they are going to explore those and confuse them as they say.

48:33 And one of the key points is when cognitive neuroscience works with an Acyclic Markov decision scheme. So that's like the partially observable Markov decision process that we were talking about earlier, it may very well be methodologically misguided. Why? Because there's an increasing tendency within neuroscience to emphasize recurrent and reciprocal neuronal processing within the newly emerging dynamical causal modeling frameworks. So how are we going to think about the fact that the brain does have these feedback loops and square the circle with the Dags and the DCM?

49:14 And that's kind of the introduction, that's where we're set up which is that Hipolito and Kirchhoff have framed and then attacked three pro arguments for modularity and cognitive architectures related to predictive processing. Benny is going to kind of take some of that energy and with a weaker version or a little bit of a different version, not simply stronger or weaker because that would actually imply transitivity of strength, but with a slightly different tack, is going to recall us to life through discussion of modularity. So this section is only going to have one slide on it and then either of you please feel free to add any comments. There's been a long history of debate on modularity in neuroscience and Fodor, who is a very influential cognitive scientist, defined modular cognitive systems as systems that are domain specific, innately specified, hardwired, autonomous and not assembled. It's not exactly the definition of modular that we've explored in some other slides, but the words are what they are and that is the Benny quote about that functional isolation between modules is what defines them.

50:38 So it's kind of like when there's more connection within than between then that's modular. And so Benny writes the present paper does not intend to defend photo's version of the modular thesis fully, probably because some of these pieces about like innate specification, hardwiring, autonomous, unassembled, take it or leave it, it was the 80s. But Benny is simply aiming to show that some critiques of modularity do not need to undermine the possibility of informational encapsulation. So although falsification of informational encapsulation leads to the renunciation of modularity, a defense of partial encapsulation would not establish a fullblooded form of modularity. So if you refute encapsulation, you have to renounce modularity.

51:28 However parcel or transient encapsulation doesn't give you strong modularity claims. However, it can be compatible with the instrumental usage of models that have modularity. So those are some of the main arguments that set Benny up to defend a version of modularity that's quite modest. And it's almost like after that kind of a modest deflationary take, the question is really, is there any value in that definition of modularity at all? So the debate isn't over whether we can discuss things modularity.

52:06 If we're going to take this different tack, then really the question is, like, does it matter? Any comments on section two?

52:17 Bleu:
I don't know. I don't want to get too deep into it. Maybe better to hold off for the dot one, but I just wonder about if encapsulation. So if something's fully informationally encapsulated, like my heart is fully informationally encapsulated from my brain, like, how does a living system function? Right?

52:38 So this partial encapsulation, if that's not strong enough for modularity, like, I don't know how full encapsulation is possible. I don't see it. Yes. Section three is entitled a golden thread free energy principle. And so we just have to go there with a Blake reference because on his gravestone and one of his most famous lines is, I give you the end of a golden string, only wind it into a ball, it will lead you in at Heaven's Gate, built in Jerusalem's Wall.

53:10 Daniel:
And then here's a drawing that he made with a mythological character walking with a golden strain. So the general idea, according to Benny behind predictive coding is that the brain uses approximate Bayesian inference to decrease discrepancy between predictions and inputs. That is one of the key contentions of the FEP. And the organism's interaction with its environment can be represented by Markov blankets. Here I am using representation and modeling when speaking of Markov blankets and consider them to be Markovian models.

53:47 So check out Benny's guest stream appearance. I think it's number one on Markov monism. And this sentence makes it clear we're talking about models. We're in the realm of instrumentalism. We're talking about Markovian models, not about whether we're making an ontologically real claim about Markov blankets, like being the structure of reality.

54:13 So in these models, Markov blankets are describing the conditional independence of internal and external states. And then it's that frustrated innovation beyond Pearl and Markovs to describe the incoming dependencies as sensory and the outgoing dependencies as active states. So what is the golden thread? The FEP is an approach for embroidering or what? Creating Markov blankets, finding them?

54:41 What is the golden thread? What is the silver thread and golden needle? So what do you think the

illusion means and what does the FEP have to do with it?

54:55 Dean:
Well, I'll speak a little bit on this. I might get it wrong, but that's okay. We're still zero. I think the predictive coding as an entailment question fits inside of the what does he call it? BCC?

55:13 Brain, brain, brain, brain, brain, brain, brain. I can't find it now in here. Anyway, I think there's a subtle and a nuanced difference between what FEP is as a process and as a principle and what FEP architecture is. And I think that is what he is trying to bring to the table. There is a difference between the architecture or the product that results from the use of an FEP process and the FEP process itself.

55:48 And once I figure out my own notes here, I can speak to what that BCC is. But I'll shut up for a second. Very well. Interesting to describe the difference between the principle and the realized architecture. Section Four the Track of a Storm so here's another single slider.

56:11 Daniel:
So there's some apparent tension between the modularity thesis and the predictive architecture. So that's what Kerchov and Hipolito described. While the thesis of modularity points in the direction of segregation and encapsulation, the predictive architecture grounds the integration of information in a hierarchical topdown architecture that unifies the mechanisms of cognition, perception and action under the FEP. So it's like what Bleu just said. Wait, if it's encapsulated and defined by its separation, then how is it part of this integrated whole?

56:50 Well, Howie, in 2013, the book The Predictive Mind and other people in other places have suggested that this conditional independence between the various levels of the hierarchical structure of predictive coding under FEP could be construed along the ines of functional segregation and informational encapsulation, which is why Fodor was brought up earlier.

57:16 Dreison argued that the predictive architecture can be modeled in terms of this causal probabilistic dependency, where different nodes could influence the adjacent levels, but there isn't global transitivity. So like the lower, most nodes are not influencing all, just the ones directly above them. However, the Hipolito and Kirchhoff paper challenge that vertical and horizontal account. So the vertical account is like the multi scale nested systems. The horizontal account is like the collective behavior interactions across within a level.

57:54 And so they aim to refute this account of functional informational modularity according to Hipolito, Kirchhoff, and let's hear from them if it's not the case. The intransitivity argument for modularity is based on Dags. However, they are going to argue that Dags are not suitable for that kind of modeling because the brain has these cyclic mechanisms and so Dags have to be replaced by cyclic models which don't have the limitations of Dags. And then with respect to the Markov blanket point, benny asserts that Hipolito and Kirchhoff argued that the argument from Markov Blankets is of little avail to establishing modularity. He will get to both of those arguments.

58:45 He kind of doesn't really worry about the courtroom as much. But the intransitivity and the Markovian blanket arguments are what Benny's going to focus on. But first, remark on the importance of scientific models. So, kind of a fun tack, but that's section four. Yes, please.

59:05 Dean. Yeah, so I found out BCC is brain's cognitive capacities. That's how he described it in the paper. So I don't think it's a rock paper, scissors issue either. I believe that predictive coding is entailed

by the brain's cognitive capacities.

59:22 Dean:
I believe that the brain's cognitive capacities are entailed by the free energy principle. So it sounds like you've got a rock, paper scissors, but that's not the same as the free energy principles architecture being entailed by predictive coding. I would have to diagram that out for you. But that's where he's saying it's not an intransitivity argument. And that's just notes to me.

59:49 And that's where I kind of ran into his corner, even though I wanted to actually do a paper later this year, a review of one of Hippolita's papers on an action that I think is fantastic in instrumentalism. But this was the moment where it was clear to me that it's not an intransitivity argument, because back then what Axel pointed out to, we have to know what entails what.

1:00:16 Daniel:
Very cool. Section five. A knock at the door.

1:00:25 Models and Modeling. We really do need to do that joke stream. Knock knock jokes like, you know, who's there? I don't know, who are you expecting? Who do you prefer?

1:00:39 In this section, Benny is going to describe some comments on modeling.

1:00:48 He writes, I do not think we can find a reliable model independent handle on the architecture of the brain. So it's kind of like saying if we're going to science, we're going to model. So let's not think that we could science without modeling. The general insight is that the interface of scientific theories and their target systems takes place through scientific modeling. So theories about the brain, the brain itself, and then the edge is the scientific modeling.

1:01:21 Now, the brain is like a special and fascinating system because it can be reflexively modeling itself. But if you think about theories of pendulums, a theory of pendulum, and then the target system of the actual pendulum, it's pretty clear to see where the modeling relation comes into play. However, again, it gets kind of strange loopy with the brain, and Benny is drawing upon various works. Some of it is the Weisberg work on simulation and similarity using models to understand the world. And also some of Benny's earlier work, for example, the ways in which Markov blankets are construed as scientific models.

1:02:05 And similar points have been discussed by Mel Andrews 2021. That was ACTU 14. So scientists are making and applying models, and so we're not going to break out of that VIP room in Plato's cave. So we have different kinds of models, and maybe some of them are preferable. But if your argument is predicated on breaking free of a given scientific model, it is something to hear if you think you have it.

1:02:40 Dean:
Dean so this got interesting for me here too, because if you look, for example, at a slice of time in an fMRI image, you could be focused on the concentration of heat in different areas of the brain. That would be one bit of information that you could take away. Or you could look at the proportion of blood in different areas of the brain which is going to tell you a little bit of different information than the actual concentration of heat, that heat bump per se. And so I was kind of curious who is a modeler here because he talks about we can't take the observer out of the observation. So again, what relative bit of information do we tend to hone in on or do we think is the more priority information to take away from

one of these slices of time representations?

1:03:50 That was really important to me right here because if you think of encapsulation as that sort of frenetic image a few slides back where all the brain is chopped up, like here's the bacon and here's the ham and right the different parts of the pig, you're choosing what it is that you think is the way of encapsulating. But I don't think that's what he's talking about. We'll explore it. But yes, taking this kind of a really strong principled stance on scientific modeling means that we can always ask who is doing the modeling? Why?

1:04:29 Daniel:
And so actually, it's not just this sterile philosophical point. It really brings us to consider the social and the operational aspects of science. So it's a very important, like, sociotechnical point. Section Six the game made the intransitivity argument, okay, we're not going to go through all the details here. We might have time in the dot one and two, but there Benny is going to focus on Hipolito and Kirchhoff's specific reply to the intransitivity argument that is centering the distinction between the directed acyclic graphs and directed cyclic graphs.

1:05:14 Benny is going to argue that these two kinds of statistical models do different things. It turns out they actually also map on to the difference between functional and effective connectivity. And so applying one sort of the model Dag or the cyclic model in a specific situation is a matter of practical exigency and methodological consideration as well as the goals and the interest of the modeler. So it's like we're 100 miles down choosing a model freeway. And then whether you take this slight difference between one topology of graphical model that's quantitative versus a different topology, maybe that is not going to be super philosophically impactful because we already have taken like the big pill which was making a scientific model or making a graphical quantitative model.

1:06:12 There's a citation to the Friston Visa Hobson 2020 paper that also describes like where the cyclic versus acyclic are preferable and Benny recaps and just basically, to summarize, there is no universal reason for extolling Dags over DCMS because the focus on functional connectivity or effective connectivity is a matter of explanatory predictive goals and interests. So scientists are using different kinds of models. And so maybe we should pull back to scientists use models and think about the implications of that rather than try to finesse out some philosophical implications from the very specific kind of last mile modeling choices. DCMS can do certain things, whereas Dags can do other things. Which one of these approaches can be used to analyze data in the context of the FEP?

1:07:20 We're going to discuss it in 35 one. Benny says I do not think Hipolito and Kirchhoff 2019 are bound to concede a nonrealist reading of DCM. Rather, the critique of how H and K confuse the intransitivity argument is pointed at their unjustified partiality towards DCMS. So it's like if you could just scapegoat the Dag, then the DCM is the savior. But if both of them are just types of scientific models that are chosen situationally operationally, as Friston described, then there is no savior model coming in to save the day.

1:08:05 DCMS are formal devices. And then there's a citation to the Emperor's New Markov blankets with yellow at all last year number 20. And so drawing attention to the difference between Dags and DCMS, which are complementary modeling tools, as we discussed earlier, they're defined as complementary could not confute the intransitivity argument. So if we have already committed to the instrumental perspective, so we're talking about our model, not about the world, then the difference between different modeling approaches is purely situational or operational. And so all scientific models have roughly similar philosophical grounding or they're part of a broad category with respect to this

intransitivity argument.

1:08:55 Nice philosophy and interesting points. Okay column in the Storm the indispensability of modularity and the indispensability of scientific models. Oh, I wonder if there's going to be like a parallelism between models and modularity. And here is like a person in their Markov bubble. In the Storm, this section focuses on a realist interpretation of DCM in terms of dynamical causal models.

1:09:30 So even instrumentalists can back both ways. We're not obliged to never talk about stances that in one certain situation we didn't prefer. It's just really wideranging intellectual exploration that's being characterized here and here. Benny does play on a little bit of an acronym play, which is that DCM applies to dynamic causal modeling as well as directed cyclic modeling. So cyclic graphs or the dynamic causal graph.

1:10:04 And he'll argue through an example that we're going to discuss not today with Alice and Bob. He argues that the modularity in the context of DCM, it's not as strong as the Fodorian isolationist concept, but in interesting and important ways it's going to be enough.

1:10:28 And so a moderate form of modularity is retained. And Hipolito and Kirchhoff argued that this weakened notion of modularity is explanatory vacuous, it's empty and there would be no reason for keeping it. And that's the bone of contention. He's going to dissent and say that the benefit of this modest notion of modularity is remarkable. So that's the claim.

1:10:58 Any comments on section seven? What would happen if we couldn't categorize.

1:11:11 Then it would be impossible to give a categorical response to that question. And a lot more. Right? That's basically what this comes down to. It doesn't mean that things aren't arbitrary and not necessarily put into the correct silos.

1:11:27 Dean:
But there is a great benefit. I don't think it's dispensable our capacity to categorize. Doesn't mean we always are obliged to do it. But when we do do it, is there a benefit? Yes.

1:11:42 Is there a cost? Maybe. But if we, if we took it away, what would the world look like then? A triangle is a triangle as a triangle, right. There would be no specificity.

1:11:57 Then.

1:11:59 Daniel:
Interesting, we'll talk more about categorization models and the parable of Alice and Bob section Eight still knitting Markov blankets. So here they return to this idea of the vertical insulation. And the horizontal insulation, like there's encapsulation laterally collective behavior and then encapsulation like an onion, like a multiscale system. So that's very interesting. And this is also where we get to this point about the scale free or scale friendly nature of Markov blankets.

1:12:47 The main reason that H and K resist this argument about the Markov blankets is based on the fact that the regimentation of states into Markov blankets
is scale free. So it can range across scales. Maybe even that is already scale friendly. Because Markov blankets are scale free, they do not apply insulation and thus the modularity thesis does not receive support from them. And so Benny concedes yes, it's true.

1:13:17 Markov blankets can be applied to basically a wide range of phenomena. However, this is overlooking a subtle point. Markov blankets in the abstraction in principle are scale free. There's no inherent constraint on their size and scope. Linear models are inherently a priori scale free.

1:13:35 It could be centimeters versus the GDP. It could be astronomical units versus temperature. Like it doesn't have a tie in to a certain spatial temporal scale or any feature for a linear model or for a Markov blanket. However, Q Dean, from stage left or running in from the audience, their application or imputation to various target systems will impose a definite scale on Markov blankets. To make a long story short, in the context of their application under FEP, not in the context of FEP, markov blankets are not necessarily scale free mathematical models because they're being used in models.

1:14:19 So even though the formal tools could be scalefree, application mandates calibrating to a certain scale. If that's the case, and it seems like it is, then counterarguments based upon the scale free nature of Markov blankets could not undermine arguments from Markov formalism soundly. So this is really nicely framed and placed in space and time. Dean, what do you think about that?

1:14:50 Dean:
As I said, first of all, I want to make sure that this claim is I never saw this paper until three days ago. Four days ago. So my guess, my dag about scale friendly and sort of whether that was. Something we should consider. It was nice to read this and have somebody else go, maybe it's something we should consider.

1:15:14 I'm going to leave it at that because I don't know if somebody's going to come along and disprove that. Because if it's falsifiable that calibrating doesn't matter and categorizing doesn't matter, I'm open to hearing that, too. But in the meantime, I think it's something that if we don't recognize the difference between the abstraction and that thing that we're focusing on right now, we can get lost in the idea that a triangle is a triangle is a triangle and nothing else matters.

1:15:52 Daniel:
Bleu, anything you want to add on this section? Yeah, I mean, I really think that just hits the nail on the head, like we're the ones putting the mark up blanket on something. And so just because something can be modeled using a Markov blanket doesn't necessarily mean it doesn't scale. And things don't mark off blanket themselves. Even, like, my layer of skin, like, cells are popping off and new cells are adding on all the time.

1:16:21 Bleu:
And so it's not a hard boundary, it's not a solid boundary. It's very fluid, like what goes in and out of a Markov blanket. So I think our imputation of a Markov blanket on a system yeah, they're scale free, means you can impute them on any system at any scale. So maybe scale friendly is the way to go, but it's not like the blanket itself is scale free. I mean, all blankets are composed of stitches.

1:16:50 Are you using big stitches or little stitches or like different layers of cloth or what? So I don't know. I don't know. I think it really drives it home. Yeah, and the paper was I mean, we can double check, but it's from December 21, so we have proof of livestream.

1:17:12 Daniel:
Dean, that you were there. Can I just say one last? Because I completely agree with what Bleu just said. I was never up an opinion that Markov blanket is a scale free. Of course it is.

1:17:27 Dean:
And it's kind of like saying there are subject matter experts. Of course there are. But as we had in the conversation with Dr. Friston, you could also say that there's a prediction matter expert. All I'm asking is for people to consider that there could be both and they could be running in parallel.

1:17:48 I wasn't trying to push back in the sense that people are wrong. What I was saying is, what else could we include to fill in the wholeness of what is happening here? That's all I was trying to point out. And again, we could take active inference and focus it completely on the minimizing of free energy and getting what we're attending to. Or we can talk about the availability piece and what, for example, when we're having new people on board to our lab, how we make that entry point so relationship based.

1:18:27 We could do that. We could make for them. We could make them prediction that matter experts before they even realize it in themselves. Now, whether we do that or not, it's not up to me, but we could. So that's what I was trying to bring up and that's what I like about this paper.

1:18:43 Daniel:
Great last section, last content slide. Isn't it something they say? Like if the newspaper article ends with a question mark, I forget which one. Is it's always yes or it's always no? But the footsteps die out forever.

1:19:00 So this is a summary. In the 9th section, Benny challenges the main points of Hipolito and Kirchhoff. Hipolito and Kirchhoff confuted the modularity thesis. So Benny is salvaging the modularity thesis from the Pincer attack of Hipolito and Kirchhoff. To support the argumentation of the paper, Benny draws upon the indispensability of a model based conception of modularity.

1:19:28 That's where that kind of science and society angle and philosophy angle came into play. Benny argues that Dags and DCMS are complementary models and the choice between them is operational, it's pragmatic, it's not metaphysical per se. So modeling is situational. We can take a deflationary approach even to how we think about science. Benny argues that when we think about dynamic causal modeling, there is modularity because of how the statistical model pulls out differential coupling between brain areas.

1:20:09 And that's not a statement about the brain, a statement about the model. Benny also challenges Hipolito and Kirchhoff's answer to the argument from the Markov formalism by showing that although these models are in principle scale free, in order to represent any specific target system, they have to be associated with interpretations that do give definite scales. So the Markov blanket formalism is conceptually scale free, but any realization application is scale specific. Thus scale friendly tickles 21 at best, personal communication and basically we're excited to live stream soon. Yeah.

1:20:52 Benny closes with just saying it doesn't undermine the claims. And this isn't like a radical pro modular thesis. It's not the isolation of brain regions and they're each like virtual machines that are totally separated. The only point that comes to light by our enterprise in this paper is that the debate over modularity needs to take the role of scientific models into account. And a model relative conception of modularity cannot be waved away easily.

1:21:23 So it is a great service and an interesting paper in form and function. We have an empty slide for the implications and questions. We have the early slide where with what we're going to discuss in 35.1 and 35.2 and it was an awesome discussion. So if you have any final comments, now would be a

good time.

1:21:54 Dean:
Do you think that when you get people who worked together as this author and the person, the two people that he was kind of pushing back against, do you think when they take it into this kind of a formal setting of paper writing that that changes their relationship fundamentally?

1:22:14 I suppose we could only ask the authors themselves. But does it have to be a debate necessarily? Does it have to be drama necessarily? Or is there kind of a moving forward hand in hand part to this? I'm not seeing.

1:22:31 Daniel:
It'S a really interesting question. I'm sure scientists and all kinds of different people are going to have different answers, but I think about the papers in their exact phrasing as like pheromones digital stigma g in the literature corpus, and then the person is like the nest mate who is weaving on. So any artifact is going to be made by that person in the past. So I could be like talking to Bleu and it's like, oh yeah, Night 2018 said this, but you just said this, but didn't Knight 2009 say this? It's not a contradiction.

1:23:12 It's just like the trajectory and the pheromone deposition of active and complex entities. And so I think that that I hope is the best of both worlds, which is we can humanize church off and Hipolito and Benny and all the humans involved and take like a compassionate and even friendly tack while also being very scrutinizing of the specifics of the knowledge artifacts that people leave. Because a lot of times there is like a gray zone where it will say something in text, but then, oh, if you're in the club then you know that they actually meant something else. Or you got to read between the lines with the methods or you have to read between the lines with the citations. And that's kind of a conflation of the person and the arguments.

1:24:04 Like when people give an overly charitable reading or even try to insinuate things that weren't there in the initial text because they want to uphold their legend person. And rather we can just kind of separate those two in how we model the generative process and the generated product. I just think that there's so much you can learn when you're wrong. That doesn't mean you want to be a serial mistake maker, but I don't think anybody that's publishing is looking to do that either. But if you're comfortable, if you're actually comfortable with putting wrong answers out there and having people kind of prove that you're wrong but you're comfortable with that, I think that makes a huge difference,
at least in terms of the culture that you're participating in.

1:24:50 Dean:
It's a lot safer if you can throw stuff out in four weeks or five weeks time. Somebody can say, no, Dean, you are wrong. We got to take that citation down. I wouldn't take it down. I would leave it up.

1:25:02 I would simply say no. In that moment I thought it was right and now I've updated my generative model. Yeah, it's like showing your work. Here's what I knew at this time and this is what leads me to my conclusions. And then someone says, well, you missed this paper from 1855.

1:25:23 Daniel:
Okay, then that updates the next round of pheromone deposition. Exactly. Bleu. Any last comments? Good.

1:25:34 Yeah, it's a fun start to 22. And it's the two architectures 2022. 2nd year of active coming up. I

mean, it couldn't get any better. That's great.

1:25:48 Dean:
Thank you, folks. Yeah. And everyone.

Session 035.1. January 5, 2022

https://www.youtube.com/watch?v=RoMCBXy-7E0

First participatory group discussion on the 2921 paper “A tale of two architectures free energy, its models, and modularity” by Majid Beni.

SESSION SPEAKERS

Daniel Ari Friedman, Stephen Sillett, Dean Tickles, Bleu Knight

CONTENTS

TRANSCRIPT

00:28 DANIEL FRIEDMAN:
All right. Hello and welcome everyone. This is ActInf lab livestream number 35 Dot One. It's January 5, 2022.

00:38 Daniel:
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 recorded and an active livestream, so please provide us with feedback so that we can improve our work. All backgrounds and perspectives are welcome here and we'll be following good video etiquette for live streams plus playing with our new affordance thanks to our Jitsey repair person.

01:08 And that'll be fun. Go active Inference.org if you want to learning more about how to participate or get involved. If you're listening to this live stream live or in replay allocating your regime of attention this way, then maybe you'd like to get involved a little bit more actively with projects including planning the livestream. So today we are in active stream 35.1. We are discussing the paper that Dean and Bleu and I did 35.0 on yesterday.

01:41 And that paper is a tale of two architectures free Energy, its Models and Modularity by Majid Beni in December 2021. And we're gonna be talking, modifying slides, asking questions, going Hinton, some things that we brought up in the dot zero, connecting a few dots and also preparing for hopefully Majid to join in the dot two video. We're going to be discussing this again next week at the same time. So let's begin with some introduction and warm up. We will each go around and just say hello and introduce ourselves as well as maybe just add something that we're curious about.

02:24 What got us really excited to discuss this paper and what are we looking forward to reducing our uncertainty about in the coming days and weeks. So I'll start I'm Daniel, I'm a researcher in California and I think I'm excited to talk about the information encapsulation and what that means, as well as to go into that parable of align and bob and see who here wants to relay that story to us and shine some light on narrativebased understandings of Free Energy principle. And I'll pass it to Stephen.

03:04 STEPHEN SILLETT:
Thank you. Yeah, I'm Stephen, I'm here in Toronto. I'm really interested in this ability to step back and look at some of the underlying processes of actually modeling that this talks about and the philosophies of that in quite a practical way. So I'm excited by that potential from this paper and also what the group here is making of that because I think it's challenging us to start to think about some foundational stuff in our work. So I'm going to pass this over to Dave.

03:40 Daniel:
We're going to just skip Dave for some audio. Oh, Dean. Is Dean around? Yes.

03:48 DEAN TICKLES:
I'm Dean. I'm in Calgary. For me, it's always trying to be able to hold up two things at once. And so for those two things in this paper or the moment of instantiation or the sort of the model slice aspect of what we're looking at and then also to instantiator to modulate. And so those two things together, what does that imply?

04:13 And that's what I want to talk about a little bit today with Bob and Align and I'll pass to Bleu.

04:20 BLEU KNIGHT:
Hi. I'm Bleu. I'm a research consultant in New Mexico. And something I'm excited to talk about today is, or maybe next week is the idea of modularity in the free energy principle and how that might work in the absence of a brain, where the FEP still applies to brainless systems and how that might be also modular or not.

04:45 Daniel:
Okay, so there's so many places to jump in, but thankfully we have some questions in the live chat, which cell begin with. And then, as per usual, we will modify our slides and just keep on adding more slides, adding more questions. So if you're watching Live, thanks again for all these great questions and I'll first bring them into this slide. So Joseph Clark asks, this is a little bit of a general question, and then we'll move to a question that's a bit more specific to the paper. So the general question is there space on either the discord or live streams to discuss active inference in inference to more traditional philosophical, psychological, linguistic or social science questions?

05:30 What would anyone say on that?

05:36 Stephen:
Well, I suppose that we do have some of those conversations as part of the active inference lab. Some of the social science questions, it can get in the weeds with too many different assumptions in the background, which they themselves could be contentious. So I think it's helpful to do some of the type of work that we're doing now to sort of think about cell. What does it actually mean to model something? What are the sort of assumptions that are even going on before we start to dive into broad sort of popular theoretical framework?

06:17 Because are we going to come at this from the position of a very low dimension modeling approach which is shed light onto things like autism, things like schizophrenia, things like types of behavior? Or are we going to come at this more from a structured principled approach where we have an ecological niche relating to an agent and a generative model? Some of those things, I think, are more helpful to start to pass so that we know how we're locating the discussion. But I'm not sure if others agree with that because it's very easy to get caught up in a discussion which is essentially located in, say, the social sciences and trying to work from there with all the implicit assumptions and get back to active inference and it can get quite heady and kind of confusing. It's maybe better work in the other way, address something from, okay, how do we take a type of modeling approach used around FEP active inference in relation to something?

07:35 What's useful from that, but that's my feeling. And I also believe it's nice to do stuff where you're doing interoceptive dialogue and working with documents in real time as much as it is through text chat because I think that also can start to get it kant quite handle the level of complexity at play. Thanks Steven. Bleu?

08:04 Bleu:
So I would push back on Joseph for a specific example of a question that might fall into this category. And also is there a particular paper that might be related to active inference in this field because I do feel like we do discuss a lot of philosophical and social science questions. I'm not sure, I guess there's some linguistics also I can't remember like a stream, it's just not like linking in my brain but we just did thinking like a state which is very social science based I think. And so yeah, I would just love to see what particular questions you would like to see address and if you can find the paper and recommend it that we discussed on the live stream, more than happy to accommodate that. Yep, the linguistics guest dream was Elliot Murphy.

08:55 Daniel:
So I'll respond in terms of affordances, I think there are probably more. So create your own affordance, modify the ActInf lab as your niche as you see fit, but there's always the information. Discord

affordance just post in general and say hey everyone, I'm gain to be curious about these ideas, I don't even know what to know. But I'm going to be curious about these different things, these topics, these three questions, and in 2 hours I'll be doing it, or in two weeks at this time. So you can always just say when you're going to be in the voice chat on Discord and maybe some people will drop in.

09:33 Or you can invite some friends, specifically, and then a little bit more formal of an affordance is we can host a guest stream or a panel. So that would be done through the com's organizational unit and we would work to plan the timing and then also set up the discussion. So it's not just like we show up and like okay, well, who is going to prepare? We can just to whatever extent is required get a jam board ready, get some slides ready, some questions that will spark the conversation and that can also invite people outside of the active community. So it can be whatever you like.

10:09 So by asking the question you've signaled that you understand that such an affordance could be important and so looking forward to seeing how you follow through. So let's go to Joseph's second question, which brings us I think a little bit closer towards the paper. It will zoom in towards it. So how do you stop overfitting on one layer of the model, for example, leg movements to avoid compromising the larger goal that an agent or person wants to do, like kicking a football. I feel this question may also help put some of the debates around modularity versus hierarchical information segregation in an analogous context.

10:52 So it's a great question. We talked a lot about hierarchical model modeling and about that lateral modularity kind of the collective behavior element and then the nested modularity which is the multiscale systems perspective. And in active inference, as we explore with the mental action paper and deep active inference, we sometimes have these nested models that are expanding over multiple timescales so that the action at one time step isn't just greedily pursuing the overall preference, but rather the preference can be realized. Or uncertainty about realizing the preference can be achieved through policy selection over a given time horizon, even when the micro movements might not be intuitive. So sort of taking one step back so that you can go a better path.

11:53 What would anybody add to that? Or we can start to diagram some pieces out here.

12:02 Dean:
I would just say don't group one or the other. Don't drop the idea of the moment of instantiation of that model slice and don't drop the to instantiator to modulate. Make sure that like I've used the expression when and don't zoom in, zoom
out. When you're zooming out, you're actually trying to incorporate longer time frames versus a moment in time. And that's how I would mitigate some I don't know that you can wipe out the overfitting problem.

12:33 There's always a potential for that. But you can mitigate it somewhat by making sure that you keep the two ideas up at the same time without one blending into the other or total focus on one or the other.

12:50 Daniel:
Right? I threw up an image from Paper 25, which was the mental action paper of San Bed Smith and this is kind of one way to address it. So let's just say that the overall goal were to kick the football. It's a good example. It works for whichever side of the pond you're on with kicking the football.

13:19 The overall inference would be, for example, the sensory observation of seeing the football far

away or of observing the foot making contact with the football at high velocity and the foot is starting in a neutral position. So just sort of like standing and the greedy gradient descender would just go from the neutral position to just kick forward. But maybe it's possible there's like a three step movement. For example, in the first time step you pull the leg back and then you move it forward two times. So over three clicks of time in the model, that is going to be the outcome that ultimately best realizes your preferences of making contact with your foot on the ball at the maximum possible velocity.

14:13 And so the policy selection is happening at the motor level. So the policy here is a parameter that's describing like the angle of the hip, that is the state that's being inferred so we won't go too deep. Hinton the skilled performance angle or the interactionism angle. But 23, check it out and two policies can be compared or a whole family of policies can be compared with one another. One policy is just move the leg forward.

14:48 The other policy is move leg backwards, then forward twice. Another policy would be like move it backwards, then forwards and backwards and forwards. Never kick the ball. Then over a given time Harrison like the time that the organism has to make this kick exafferent expectations can be calculated for different policy sequences. And again, if it turns out that moving the leg back one step and then forward two steps makes contact with the ball at higher velocity, then at the level of deep policy selection, that three step sequence will be selected over the just move the leg forward sequence or the back and forth not kicking sequence.

15:34 So that's a mechanical version and it's also the kind of model structure that applies to not just motor actions but mental action. So I hope that gets a little bit towards it and also starts us towards this discussion of modularity because where is the modularity in what we just described? So Stephen and then anyone else who raises their hand or throws out a string of emojis. Yeah, this is a very useful examples a, because you see, it's about phenomenology. And it's interesting because traditionally philosophical, ecological perspectival type approaches averaging out over social approaches aren't phenomenological.

16:28 Stephen:
And phenomenological ties in more with our best guess approach of how an agent is experiencing things. So what you just mentioned here, I think this is quite good for kicking the football, is I'm trying to work out how to kick the football. What am I trying to do? As it said in policy selection, I'm trying to work out the best way to do it. And I may be unaware of what I'm paying attention to in trying to help do that.

16:53 There might be some subconscious processes which are helping to calibrate it. However, once I've actually mastered that performance, what I'm paying attention to may not be how to do it. I might be in the flow. What am I paying attention to is how do I look up and just kick the Bull towards another player? So I think I'm wondering what people's thoughts are there in terms of how that changes things to now be in an agent based mode.

17:23 Daniel:
Good question. I think it also relates to the event based cognition. For example, Martin Boots and what he talked about, the micro level is indeed the policy of each muscle and joint being selected to write something. However, there's a modularity that arises from cognitive chunking of complex motor actions, for example, into broader, more handleable units. So like writing a letter is like a unit of motor actions.

18:03 It's actually a really complex sequence of motor actions and then writing a word is a given event that subsumes or entails or requires or is supervening upon lower levels policy selections like which way to move a muscle of a thumb. However, it's the increasingly chunked and modular, perhaps even semantic levels that appear to arise more to our phenomenology. Which is why we, for example, reach for something and a whole host of processes play out without us needing to micromanage the motor actions. Yes, Dean.

18:57 Dean:
I would just kind of I think, to Stevens point, I think what we are asking here is does the mind or can the mind go in two directions? Namely, do we start with a frame or an architectural scaffold or a model? Or does the process of what we're watching I e. Kicking a ball spectralize the relativity ie. Does it confirm what the edges are?

19:27 So those are different, completely opposite views of things over a timescale. So then I guess what we have to ask ourselves is does the representation act as the takeoff point? Meaning, do we start with the model? Do we start with that scientific view or does the representation evolve as the results sort of more of the creative view? I think we're capable of doing both.

19:56 In fact, there's lots of evidence that we do do both. So I would come back to do we modulate? Yes. Is that a process? Yes.

20:06 Can we take slices of a modulation exercise and see them as representational and modeling? Yes. So that's all I would point to. I don't know when the cognition is steven? When it's kicking the ball.

20:25 Daniel:
Banksten, Stephen and then anyone else. Yeah. Well, this transition this may be part of what changes. I suppose this is one of the interactions things is it depends on the nature of the situation. But everything at some level which is interesting is hidden in active inference.

20:44 Stephen:
And we're trying to get some purchase on that which is interesting as opposed to it being out there as knowledge. And we somehow know it. It's like, okay, what am I perceiving will always be more hidden states than I can ever really know. What am I trying to do? There were more hidden states.

21:03 What am I paying attention to? And I think what's quite interesting is what is at the realm of being available to us in our consciousness. Okay, so the sort of thing that Daniel was talking about, the sort of process, the sense making process which is present when it's not immediately obvious how to kick a ball because Messi doesn't do that. Messi knows he feels it right. But there's something really interesting about the scale.

21:34 And I think my feeling is we have a meso middle scale. There's things which come out of our awareness or harder to purchase or get a grip on as they become faster and as they become slower. So what am I paying attention to? There may be something that my unconscious is sort of aware of that phenomenological feeling about how the events is going and how my stomach is feeling waiting for the next meal which is sort of too flow for me to really notice. And there's other things like we're saying we should just biological at speeds faster than the rates at which conscious awareness operates and we've sort of got both of these and that moves a little bit depending on how I take my attention in the world.

22:28 Daniel:

Thanks Steven. Yes. So we have a few different axes or continuum here. There's the phenomenological or what is experienced and then there's sort of the third person impersonal where it's more just about what's happening in the model and we don't even associate it with a conscious experience. In this mental action paper it threads the line because it is talking about computational phenomenology.

23:02 However, this is the structure of deep active inference policy selection models which don't need to require any kind of phenomenological experience. So Bleu and then we will continue to the next slide. So just in thinking about agent systems and information encapsulation it seems like to be part of the same system there must be partial information encapsulation. Like you can't play a basketball game with a Dutch of other people without sharing information such as the position of the ball and the rules of the game, et cetera. So the partial information encapsulation to what degree, what percentage is information encapsulated between individuals, between modules of an individual, tissues of an individual and so forth?

23:58 Bleu:
I really wonder about that. I mean, even like you think about the butterfly effects we're all sharing globally information such as climate change or this type of thing. So there's information at a global level that affects every single one of us because we're all part of the same goal system. And so there's dot two be some kind of partial encapsulation I think, just to be connected in the system. Great, Steven, that's a good point Bleu makes there because there's only certain things available at certain temporal scales to make some of these.

24:40 Stephen:
The temporal depth of being aware of the ball in a practical sense is a certain there's a certain at some point it just becomes noise, it's too fast to sequences. There's no point getting outside of actually processing sensory information itself at these faster levels. And as happens with all the uncertainty and error prediction that goes up the
chain there's a certain goldilocks zone right force knowing how the ball is going in the game. And if I'm standing and watching the game, there's a sort of a Goldilock speed which is probably relatively slow. Just like in a soccer game, if I'm sort of running down the wing and not getting the ball a lot but when the ball's actually kicked to me, I've got a player coming in to tackle me, I've got another player running, and I've got to do something with it now.

25:32 Bang. I've got a window that's dot two happen in their shortest period of time. You know, the regime of attention and the action policy selection is in the terms of like half a second, maybe milliseconds, of which some are not even available in our conscious awareness, unlike maybe the tracking of the game, which might be of a window of 510, 15 seconds, maybe longer. I think that in itself would that not itself create some sort of modularity?

26:04 Daniel:
Great question. So we explored several different senses of modularity in the dot zero. So there is the physical connectedness, like the anatomical connectivity, anatomical modularity. And then we talked about the effective and functional, which are two statistically different they're not interchangeable, but there are two different ways to talk about modularity. So now we're exploring how these notions of modularity line up with potentially the nesting of multiscale systems through space and time.

26:45 So I'm pulling up one of the figures from Ramstead et al. 18, answering Schrodinger's question, if I can just resize it properly. And so here on the x axis is time, and on the y axis is spatial scale. And what this graph is laying out loosely and it's been described in other papers discussions since is that

things are kind of existing on the line where we're seeing that smaller things are happening faster and larger things are happening slower things that happen over continents are happening over longer time scales and things that can happen at a subcellular scale. So there is kind of this natural relationship between spatial and temporal scale of processes.

27:39 And how does that relate to the modularity that Bleu was describing? If there's complete encapsulation of a given module, if such a thing could even exist in reality, is one question. Now, if something could exist in our model, of course it's true we can develop a model that has that connectivity amongst variables. Doesn't mean it's the best model or is the one that is the perfect territory description itself. But it's not.

28:11 It's a map. And then if we had no interactions, that's kind of like saying that it's just encapsulated at the next scale up. I'm sorry, no encapsulation within a level is kind of like saying it's just perfectly encapsulated at the next level. So in a way the partial information encapsulation is the gray zone that everything is going to be existing within Stephen and then anyone else? Yeah, actually, because they've sort of gone back on this on this particular diagram to some extent after feedback from Casper Hess.

28:49 Stephen:
I think this is really where there is is a because this continuum, this idea of a continuum going out is what I think active inference sort of changes how we see that. And it's hard because when we try and map things like what Maxwell was doing here, he was taking stuff from the social sciences and the different approaches that are mainstream and this is how it pans out. But this is often because this is what we think of something from the outside, we see from the outside group behavior patterns. We see an organism, we categorize it, we make models of it, and they sort of stack up in this way over time, in time and temporal and physical scales. However, from the perspective of the dynamics, are we having a different Goldilock zone within smaller and faster temporal dynamics in terms of what's actually happening?

29:56 And when that means something is out in the niche, we may see stuff dropping out from that, but there's no reason, for instance, where niche construction is not being under girdled by rapid decision making at real time. Just lieke de Boer players are all making choices on the pitch around where they run. It changes the way the grass is going to get worn down. Okay, so it's interesting actually now looking at so what is the replacement of this diagram? Has there been one that doesn't have this kind of micro macro and actually is able to have an action orientated me so that can meet the requirements of what we're talking about?

30:49 Heuristic ontologies and ontological pluralism. Well, where is that? Where is that being described? And I think that's a missing link at the moment. Great.

31:01 Daniel:
I think that this takes us to a good return on the Markov blanket scale free or scale friendly debate. Because just like you said, Steven, somebody talking about a cellular scale and the kinds of perception, cognition, action happening at a cellular or an organismal scale. They're not saying that niche construction doesn't exist ecological scale, niche construction, because we could also think about tissue levels, niche construction, rather that the regime of attention of the scientific modeler is being directed towards a given kind of modeling. And so that's sort of how we take something that is a unifying theory, like free energy principle or a scale free or a scale a priori model, whether it's Markov blankets or linear regression. But in any implication to a given system, there are going to be timescales of analysis that just do and don't make sense.

32:16 And that's where we operationalize the Markov blanket. Or as Beni wrote, although Markov blanket states principle scale free, meaning there are no inherent constraints on their size and scope, their application or imputation to various target systems will impose a definite scale on Markov blankets. Dean yeah, and I think, again, that's why I want to talk a little bit about the instantiation moment sort of piggybacking on yours and Stevens comment. When we apply a Markov blanket, we can ask the question from an encapsulation perspective. Did you see what I saw?

33:00 Dean:
It's a question. We're both behind a blanket. We're both wondering if there's some agreement that we've gained, some sort of a counterfactuals alignment. I could also say to you, did you see that? Which is it may sound like almost the same question, but it's not the same question.

33:20 They're radically different questions because one says, are we in agreement on what's being encapsulated learning? Are we forming a co contextualization. Or the other one says, I'm not sure. Right? I'm not sure what you're seeing.

33:43 So to this question of scale, free energy is moving us, I think, to that place of coexisting context. But I think the critical thing is we've talked about this so many times. Don't confuse the something or other, the map with the field or whatever. I get lost in it all. But the bottom line is, can we do two things at once?

34:11 I know we can. Our brains can realize that applying a partition versus or with in conjunction with what is that slice of time as a activity question? And then when does that relativity question appear at the beginning? Is that our takeoff point or is that our conclusion? That's all that this paper to me does.

34:36 Is it says, at what moment do we employ categorization?

34:43 Daniel:
Interesting, Dean. Thank you, Dave. And then anyone else?

34:52 Speaker E:
Yeah, to Dean's comment, when I asked, did you see what I saw? The proximal poll of your attention is being invited to be projected into me. So you're seeing it through me. You might compare that to what some crazy Russians were doing 100 years ago. They were trying to get the notion across that very few people are conscious more than a few times a year.

35:32 And they said, well, look, I can explain away your impression that you're conscious a whole lot. Here's what I can say. I can say, hey, are you conscious? The very fact that I asked you are you conscious? Causes you to be conscious.

35:51 It shocks you into consciousness and you wake up and you say cell. Yes, I am, of course, because I force that on.

36:02 Daniel:
Even.

36:06 Stephen:
And this takes in the idea of what is the adjacent possible, what is available in that ecosystem of

awareness that we're talking about. So just like you said there, if someone says, did you see that? That can take someone into a sense of like I'm trying to work out often, particularly if there's a power difference between people, what that other person's now wanting me to see? And I've seen this a lot, actually. When we're doing work in South Africa with communities, one of the first things is to let people ask them a question to get them to a point where they're actually telling you what they think, not what they think you are thinking about what they should be saying.

36:58 So where is that attention? Just like, say, where is it in terms of being conscious as an awareness? And how much of this scale is cell, what's available, and what's going to be an impact in terms of the adjacency? So a cell has some awareness potentially, and maybe even some active inference at the kind of the actual organ level, potentially. And maybe further it will have an impact maybe in terms of the way cells divide on the nature of expectation, yes.

37:35 But it hasn't necessarily got any. Trajectory to adaptively couple it's not in its adjacent possibles. And I think that is quite useful in terms of it starts to open up in terms of the information either temporarily how much is something separated by time spatially, how much is by space, by suppose, also by statistical contingencies and the ability to adapt and interact, those types of things. What is either within or adjacent and what becomes outside of that. I think that starts
to give some of these scaling modularity questions just maybe an applied direction to come out.

38:25 Daniel:
Thank you Steven Bleu. There is a huge fundamental difference between asking someone what do you see? And do you see that even if you don't give them that, you're still looking in a direction of that, right? So what do you see? Like let someone look at their surroundings, take stock in what they see and give their independent observations versus just even Lieke de Boer see that and you look over it in a direction at least like you're directing someone's attention with your question.

39:03 Bleu:
So asking an open question versus a directed question can give very different answers. And I wonder what the impact of that would be on modularity or even just an information sharing. Like there's more shared information in. Do you see that or do you see what I see? That's like an intention to share your generative models at that point versus what do you see is actually trying to take stock in someone else's model.

39:35 It's just an interesting thought. These all points using the example of communication and visual perception to where we have partial information encapsulation. If the two entities were totally encapsulated, they couldn't communicate. If there was no encapsulation, such a question wouldn't be required to be asked. But there is a specific type of edge in this network.

40:05 Daniel:
We can almost think of these like two modules as like maybe the two generative model models of the individuals. And there's this connection when some of the modules are connected and it is a nice how we're kind of exploring these subtly different questions, I think. Did you see that? Is that is corresponding to an external states like an observation. Did you see that red blur in the sky?

40:35 I don't know what it was, could have been a comment, but did you see that versus what I saw? Well, we know that you see with your mind generative model of vision and whatnot and so especially when we're outside of the signal processing paradigm of vision did you see what I saw? Is like quite literally asking is your internal hidden state related to mine? Are we seeing the same thing? That

doesn't mean are the photons hitting both of our retina means do we have a shared generative model of visual objects?

41:12 So Dean and then Dave, just one last thing. That's a great summary. First of all. Secondly, when we're talking about what is the nature of the partition, I think as a group we're still trying to define what we hope is not completely definable yet. Do you want to understand what that partial encapsulation?

41:40 Dean:
I'm not saying it's undefined. I'm not saying it's zero, although down the road I might say we're passing through zero because that's what I'm kind of moving towards. But I think when we partition, that partition is not static and it's not and the definition of it is to leave it somewhat undefined. I like your explanation better, Daniel, but that's what I think we're trying to move towards here eventually. Great.

42:16 Daniel:
Dave, do you want to add some in there? Okay, so Bleu, or if not Bleu, then Stephen?

42:30 Bleu:
I went already. I'm good.

42:33 Stephen:
I suppose just pushing a question back. We talk about this encapsulation modularity and where we put that by putting the blanket somewhere seems to be kind of implied by that. So that kind of is done through a way of speculating on where the observations are generating some sensory states and where we are in terms of the action dynamics at play. How much is this dropping out of the literal availability at a certain scale and then we make the blanket around it and how much of it comes from structuring the blanket? In terms of how we implement this, I think that changes what modularity may or may not mean because I think that how those separations and modularity are done.

43:44 Is it a case of how parallel processes are happening and are being integrated and they're moderately, almost independent? Maybe certain senses are independent. And how much is it that they're independent because they're separated at an integrated level by temporal physical space?

44:12 Daniel:
Great questions. Are these partitionings a priori model or do we merely specify what we're going to measure? And then the blankets? If we're using the technical definition of a Markov blanket, like the set of variables upon which two other sets of variables called internal and external states become conditionally independent, in that case you don't need to specify which nodes are blanket states. You just make the measurements and then relative to a target set of states, some other set become a blanket with respect to a third external type of states.

44:57 So Dean and then Bleu. Okay, I'll be super quick. This idea that our minds are able to categorize so world of correlation, like in backslashes when we're looking at it symbolically or interactions, iehons. These are symbolic knots to the market Markov blanketing. So the instantiating or partitioning of an partitioning and applying I'm sorry.

45:30 Dean:
So my example here might be a little strange, but be generous. When yellow becomes orange in an fMRI or a rainbow, which begs the question is a rainbow a piece of encapsulated information? Okay. Is that representation transitive or intransitive? Okay, so I e.

45:58 The claim that the most important color in the rainbow is yellow on one end, on the other is at the end of all rainbows must exist prisms made up of unicorn, sea serpents and flying monkeys or maybe free and energy and dynamic or principle. See where I'm going with this. Our minds are able to do both ends of that continuum at once and that's what I think where the architectures and the process both come into play. We can look at this from a more of a did you see what I saw perspective. And most people won't say they're comparing flying monkeys to free energy dynamics, but people can.

46:49 And I think maybe that's what affordance our minds are trying to set up here. It certainly is with how we encapsulate the information, how we as the observer choose to do that and then try to gain some consensus around that. Thank you for your patience.

47:08 Daniel:
Late nights in the Dean household.

47:14 Bleu and then Stephen. Tickles me. Just tickles me.

47:22 Bleu:
So I have to just comment on Dean's comment really quickly and then I want to go back to Klaas. Stephan said so when yellow becomes orange in an fMRI now, I don't really know a lot about how fMRI works, but I don't think that there's actually any color spectra applied. Like yellow is 570 to 590 nm in the electromagnetic spectrum. But I don't think that fMRI actually turns out yellow. I think it actually turns out something between zero and 256.

47:51 So like in terms of light intensity and we just fakely apply yellow to that. That's correct. Right. So it's an arbitrary distinction when yellow becomes orange or rainbow. This is just something we made up just to share our generative model, like to share information about the picture that we're seeing on the screen.

48:15 But going back to Klaas. Stephan said. And then this is going to hit on a point that Dean is going to love. Also, because we apply the Markup blanket to the system that we're interested in studying, like to the organism, the individual, the heart, the liver, the cell. To define what makes the internal and external states conditionally independent.

48:36 We apply the blanket, therefore we create the module. Is that the same or is that not the same?

48:48 Dean:
I vote same. Are we engaged in module projection or module discovery and not even or what other ways do modules apply? So Stephen with raised hand and then anyone else? So the two interesting points just been made there by Bleu and in that moment and Dean when we say doing both at once, I think there's also times I would argue though that we're able to do both and some of these processes can be possibly be run in parallel. However, the regimes of attention at certain scales we can't do together in the same way we almost have to go from one to the other unless there's an adjacency between the two types of regimes, I would say, to enable that to happen.

49:49 Stephen:
So if I'm thinking about something, for instance, that's quite somatic and then I'm thinking about something which is quite abstract. Over time, I might be able to train myself for that abstract to have a marker in the Sematic that I can then interface with. But I'm still integrating two SEMATICS together

in the Sematic regime. Or I might have a model of the Sematic in the kind of Ocular visual modeling mode and I can imagine the two, but in the same moment I can't hold both with the same type of embodiment. So that's one of the things that I think is quite important to wonder and then also once we then get into these is that ability to configure is that the Markov blanket?

50:45 And this sort of takes us into sense finding, sense making type of work is the sense finding. Okay, how am I even sensing what to do in this moment? And we have that and then I start to sense and then I'm sense making how to do it and then I need a skillful practice and maybe I can just do it. So some things are more or less in and out of. Is that sense finding sort of aligning a blanket by basically aligning what the sensory and action kind of states that are relevant are going to be done and then are we maybe have that set and now we're in a kind of more generative sense making, maybe even just skillful flow.

51:28 Okay, I've got my general blanket in place. I'm in a skillful flow now, right? And that sometimes takes time. And it's also maybe we can only switch attention to something that's in a different regime with a certain speed. So anyway, both those points really struck.

51:51 Daniel:
Me the
speed of attention. It's really interesting. And Friston and others have related that to the rapid oscillations like the gamma cycles in the brain, which they don't happen 1000 times per second, but they do happen more than once a second. There's a certain number of times. And it's interesting how that lines up with our perceptual capacity.

52:17 Like when something is alternating and rotating and then it goes from sort of black and white to gray. There's a moment where the perceptual speed is just not able to see that anymore as two contrasting states. But it's one blurred state and it doesn't have to do with the photons hitting the retina being blurred, it has to do with the generative model efficient. Dean Steven, I completely agree with you and I inference back to sort of Wittgenstein's illusion of the duck rabbit and how do we put a Markov blanket between those two representations? You can't see the rabbit when you see the duck and vice versa.

53:01 Dean:
And then that leads me to the parable of Bob and Alice. So I just kant to put that in there. I think that's a great time. Let's move Bob and Alice up. Let's put Bob and Alice on their own page with a doc.

53:15 Daniel:
I don't want to even bias which one it is with this representation. So would you like to maybe set up the Bob and Alice? Or we can look up the full. Text, go with the text because it's really clear. Yeah.

53:30 Awesome. All right, so here we go.

53:43 All right. We're going to assume there are two neighbors, bob and Alice. So A and B kind of a classic quantum parable. Every night when Bob is beginning to brush his teeth, alice begins to read a section of A Tale of Two Cities at the adjunct blanket states. B contains Bob beginning to brush his teeth in his flat and state A controls Alice, beginning to read the book at hearse.

54:08 Let us assume there's no causal relationship between the states A and B. Given the two states are segregated, there may or may not be a common cause that pre establishes a harmony between A and B,

say, when. What happens in A and B are both bedtime activities, coordinated because of various cultural and geographic habits. However, the assumption of common cause does not need to affect the present discussion, because what is important for us is that information processing in A is inaccessible to information processing and B, and vice versa. This is in harmony with satisfying the assumption of encapsulation and the assumption of modularity to some interesting extent.

54:46 So, Dean, maybe unpack or explain what you think is interesting. And I'll start to get some nodes and edges on this slide. So I don't know which the duck or the rabbit, which is Bob or which is Alice, but to the observer, there's information encapsulated in that which can be broken down into A or B. Then the question becomes one of so how do we modulate? How does the switch between those two internal representation held in one block of pixels work?

55:24 Dean:
How do we partition when that potential for one or the other exists? Did you see what I saw? I guess we're coming back to that question.

55:42 Daniel:
Klaas. Stephan and then I'll be developing these notes a little bit. Yeah. And what we see cell I'm going to add one thing here, sort of related, I think, is if you look at that rabbit and that duck okay. Cell the rabbit is forward looking and decisive and the back is backward looking at the past.

56:08 Stephen:
Because the visual grammar that we use in the west is mostly that the left of a vertical flat image or flat piece of paper is the left is the past, the right is the future. So even that flipping, the nature of that rabbit is caught within a cultural frame, which would be different if the duck was facing the other way and the rabbit was looking backwards.

56:42 I suppose there's something interesting there. Now, the rabbits like looking back in the past, right. So there's something interesting there about some other kind of the contextuality, I suppose, of how things are. So I just thought I'd add that in. Yes.

57:06 Daniel:
As the symposium with Friston discussed a lot. Illusions reveal our prior. So if you're trained in ballerina dance and it's only a clockwise rotation, when you see the rotating ballerina, you're going to see that that's going to be having overwhelming posterior likelihood given the ambiguous visual stimuli. Or if cubes are always facing down into the left, you're going to perceive that when you see an ambiguous cubic stimulus. And so it does matter these deep priors on how we perceive even visual stimuli.

57:41 Bleu.

57:45 Bleu:
So there's an important component, I think, that's missing from the Bob and Alice paradigm, and the author leads to it in describing shared culture, norms, bedtime, et cetera. But there's Bob and there's Alice and then there's the niche, the environment, essentially, that they both reside in the environment and in the environment it's 09:00. And so something interesting that it reminds me of is that I was reading that in transitivity paper. I was just looking for it. Daniel maybe you have it in a slide and can inference it here, but they talked about intransitivity in various contexts.

58:23 And we gave the example of rock, paper, scissors, but they also mentioned intransitivity in the Laje WALTERA population model with the fox and the rabbit, right? So normally you don't think about that as being an intransitive relationship. It's like the foxes go up and the rabbits go down and the rabbits go up and the foxes go it's like this cyclical thing between the fox and the rabbit. But they mentioned the importance of the environment and how it's just normally considered. The environmental resources are constant, but that's not normally the case.

58:57 And so eventually, if the rabbits eat all the grass, the population of rabbits will go down, unrelated to the population of foxes. And so it's, I think, important to consider in Bob and Alice in this relationship, like, what is the role of the niche environment and then does like this third hidden state, like, okay, we see Bob and we see Alice, and they don't know anything about each other. So information is encapsulated. Like, Bob doesn't know anything about Alice, alice doesn't know anything about Bob, but they both live in the same place. And that's what I was saying earlier about the butterfly affect and climate change.

59:33 Like, the environment plays a role in the distribution of information between Bob and Alice.

59:44 Daniel:
Great. So we can look at two different stories. And I think this totally gets to the difference between realism and instrumentalism as well. So what are the difference between these two? Cell?

1:00:02 First off, it's funny that the book being read is Tale of Two Cities because that's like The Tale of Two Dean Cities, like we read. And it's also invoked in the title of this paper. So there's going to be two stories of red lines. These are two narratives that can be told scientifically by modelers. Okay, so no one's disagreeing about the niche.

1:00:29 No one's saying, well, actually they're in one s on the moon and Ines on Earth. So we're talking about the same niche. Now let's imagine that Bob and Alice were two brain regions, B and A. So we observed brushing and reading to be co activated, they're co expressed behaviors. And so what does this edge reflect?

1:00:54 We have an answer there. It's the functional connectivity function connectivity force. The 94 functional connectivity is a temporal correlation between spatially remote events. So that is functional connectivity. The alternative is to refer to effective connectivity which is active inference of one neuronal system over another.

1:01:17 Let's go back to Bob and Jelle. So this is a function connectivity edge. If there was an effective connectivity edge, it would have none because although they happen at a temporary correlated time, let's just say they each did it 90% of the time. So overall, like 81% of the time they're both doing it. And so there's a really high temporal correlation.

1:01:42 However, the 10% of the time when one is not doing it, it doesn't have an effect on the other. So they're conditionally independent. So actually the effective connectivity wouldn't have an edge if it were calculated appropriately. So function connectivity, we see an edge. Effective connectivity, we don't see an edge.

1:02:00 And then there's the third story then Dean, which is a causal mechanistic story, which is the niche broadly being the time zone and the human circadian rhythms and all these other features. The niche is influencing Bob and Alice independently. It's like a confounding variable. And then that is

what causes Bob to brush and Alice to read. And so yes, we do get this temporal correlation arising from a latent causing variable.

1:02:39 And so how does that relate to neuroimaging studies when people find that there's functional or even effective connectivity amongst brain regions and then cast that as a mechanistic story about what is actually happening? Dean and then Stephen isn't the effective. I'm asking because I don't know, is the effective connectivity here on a z plane? Meaning from the observers standpoint, the effect is this XY relationship because that's time, right, the changes from my eyeballs through that screen into that slide and then beyond on the other side of that, is that not the effect of connectivity? I know we can't show it here because we have to work on 2D rectangles, but isn't that it correct.

1:03:43 You could think about for any given edge, like between brushing and reading, there's going to be some FC score between zero and one and then there's some effective connectivity score between zero and one. And so you could have cases where that edge is like a zero comma zero. It doesn't have effective nor function
connectivity in a given experimental measurement. And then you could have high for both. And it always has to be described in terms of the measurement that's being taken because the temporal correlation doesn't exist outside of the time series that the correlation is being done on.

1:04:24 And so that is where Beni introduces the modelbased science. It's like if you're talking at all about the connectivity statistically defined, you're talking about a statistical model on a specific experiment. So even if you're using a tool like a Markov blanket or linear regression that is not posing a priori scale in that time series, there is an a priori scale. It's the specific time scale that you measured. So yes, the edges can be of different kinds.

1:04:54 And in neuroimaging, again, as we talked about, dot zero, there's the anatomical, the functional, and the effective. And so wouldn't that be simple if they were all the same? But it's just literally not the case. There's brain regions that don't have direct connections to each other that have temporal correlation, and there's ones that are directly connected, but they don't have temporal correlations and every other combination. That's why we have to do empirical measurement.

1:05:20 So Stephen.

1:05:26 Stephen:
The difference as well as now we've seen niche being brought in when we have functional connectivity in the brain, it's kind of assuming that it's all brain processes. So, okay, you've got the brain and what's going on and the connection between different areas. Now if we start coming out and we start looking at well, there's active inference with Markovian approaches, okay, there's brushing. But brushing is an action, right? Reason is an action coupled to a niche and the body and the generative model.

1:06:03 And so you've now come and the niche it's not just that there's a niche out there that's also interacting with a kind of a brain based process. You got a niche, but there's also then another recursion where, okay, we're now looking at the idea which is maybe being formulated conceptually, more of this whole thing happening and this whole thing, this whole process, this model is in a niche itself, okay? And I'm creating in this model of this story a functional connectivity which may be substantiated through data if science is used between brushing and reading. Because the story has put that system of information to me because I've never met Bob or Alice and they're most likely fictional. So there's an interesting move from what started out as brain regions being looked at as function connectivity, trying to then think, what that's doing?

1:07:11 Because there's something out there, these hidden states to active inference lab agent, where you now have action to give you a grounding to jumping back out again to another sort of conceptual system of information which we may be working with to look at ourselves. So I think that changes. Where does that word niche fit?

1:07:42 Daniel:
Great. Thanks, Dean. I just think that if I'm willing to incorporate effective connectivity, I'm actually looking at the observer observing. So somebody throws me into a Cat scan machine, starts taking slices of my brain. I'm sure they're going to be able to point out some sort of a functional connection between what image pops out.

1:08:14 Dean:
When my brain is focusing on the rabbit or my brain is focusing on the duck. That functional connection will definitely be able to show up in terms of some sort of differentiation between those two ways that I'm perceiving that image. I think it's harder and maybe there's because I don't know, but maybe there is some way of being able to show how the brain is swapping building the Markov blanket in situ. I don't know. But if there is a paper about that, I'd like to read it.

1:08:56 I know the observer in Betty's examples here is swapping at some point between am I looking at Bob, am I looking at Alice or am I looking at 09:00 or am I looking at the swap? And I'm not sure if it's easy to be able to show the swap part, but it's definitely there. Great Bleu. Did you want to add it? Something about the intransitivity of the voltera ecological modeling.

1:09:29 Bleu:
I had already mentioned it. Just putting the image up. Yeah. Okay, great. Steven.

1:09:35 Stephen:
It'S going to be a little bit of a question, but it's rhetorical if you want it to be. But if we've got here the relationship between the brain processing or the body processing of the organism, there could be effective connectivity because there's some common relational processes. If we're talking about how they're in their niche and maybe some loose way that feedback loops can reverberate through the buildings that they're in and the social malar, you can see the niche coming in. And then if we then go to cell, what in this system of information that we're engaging. So if Alice and Bob are coupled in our system information here, that could be functional because it's within the variables that I assign to Alice and Bob in whatever way that I'm embodying this learning making.

1:10:44 So I was wondering if those three it sort of ties in a bit of what you've got here, but I kind of feel it's useful to it starts to think about where Karl Friston coming from when it was kind of trying to get at what the brain's doing in response to and really get at what's going on in there to when it's something which is actually happening to something again, which becomes kind of an abstracted level and I don't know which of those is closest to what is normally being taught. Does that change between the actual nature of the system? Do we have a way to think about that? Or is that speaking to this process that when you just have DCM models and you just have these kind of informational models that has to be kind of set, you have to kind of tell it and believe that what you're talking about. The beauty of active inference is I have a deeper anchor to help me tether all of those three.

1:11:57 I have an embodied way of knowing how it is to imagine. I have an embodied way of knowing how to brush and read. I have an embodied way of enacting motor skills in real time to make the brush

and reading even possible. And that's something that the previous models hadn't really got a plausible mechanism to explain until we got active inference. DCM doesn't seem to have that ability.

1:12:30 It's all still kind of untethered information based approaches.

1:12:37 Daniel:
Okay, interesting. So I think these three tale of Three cities now we have a functional so these are predicated upon observations of so first to Stephen's point, yes, we could think about brushing and reading as affordances and embodiment. And that is something that active inference brings to the table, which is like the ability to zoom in on one of these observations. And it's like cell. We're not just studying the observation of Kuchling.

1:13:13 There's an entity that's engaged in this skillful action, that's culture, and that just takes you a million other places. So, yes, active inference is a development on what Friston blanket others have been doing for 30 years. We really have to be careful whether we're using terms in their technical statistical sense or not. Like, just to show how easy it is to get mixed up. You can say, well, I mean, brushing and reading are correlated, so it's like they're effectively connected, but they're not.

1:13:45 That's called functional connectivity. Functional connectivity is the temporal correlation. And then here's how easy it is to get confused on the other side. Here's a story about the world where Bob does call Alice, but we are not wiretapping. And Bob says, hey, I'm brushing, you should read.

1:14:01 And so it turns out that in this world, not just are brushing and reading functionally correlated, like they have a time series correlation, but actually brushing does induce reading through a mechanism that we didn't observe. That sounds like a functional correlation or a functional cognition. It's not. It's an effective connection how it's technically defined the influence of one system on another. And so, yes, function is happening, action is happening, but it is very important that when thinking about these edges, people are accurate because these stories are all happening at the same time.

1:14:48 And different experimental designs or statistical analysis might not be contradictory to each other. They might be totally complementary to each other. Somebody might be describing the exploration of how brushing and reading come to be, and somebody else might be talking about the functional or the effective connectivity or all these other kinds of pieces. And so I agree, active helps us understand the nonrival risk dynamics of all these different descriptions. However, we're going to be on the ground floor forever if we can't be clear about what those different descriptions are and adjust our regime to these different important parts of the system.

1:15:34 Dave and then Dean.

1:15:39 Okay. Dean and then Dave if you unmute later. So Dean and then Stephen yeah. So could you put a second thought bubble under EC? And could you be, hey, I'm 09:00.

1:15:52 Dean:
Are you?

1:15:56 Because that to me is the effect of connectivity. I keep the hay. I'm brushing you should read, but also there should be a second one. Hey, I'm 09:00, are you 09:00? Cue.

1:16:08 That to me speaks as much to the effect as opposed to the function.

1:16:16 Daniel:
Yes, good point. And depending on how literal you want to take this metaphor or how you're imagining the story Bob and Alice, or how close you want to tie it to neural systems, one could imagine various pieces. This is just a highlight. Like that red is this causal chain active inference that makes a difference. The actual phone call that induces reading.

1:16:38
That's unobserved in this experiment. So fMRI is measuring blood oxygen levels, dynamics, Bold signal. And so that's not even neural activity. Now read the SPM textbook because that's how you infer neuronal activity from the Bold signal. But it's not what's being directly measured.

1:16:59 Dean:
Right, but I just want to add so even the observer is 09:00. So now Bob is 09:00, alice is 09:00, and the observer of Bob and Alice is 09:00. That's what I kind of want to bring into the conversation. Yes, totally agree. Like here's our happy scientist.

1:17:27 Daniel:
Don't know if there's a better icon to represent the scientists, but right. They are going to be observing. They're the ones who are making all of these observations. And it's somewhere between misguided to dangerous. When it's like, well, this is simply how it is.

1:17:44 It's like, well, no, there's the smiley guy who's projecting that who's modeling modelbased science. Science is a social practice. Humans doing science. This is really important to keep in mind. Otherwise you might have, you know, a smiley and a frowny.

1:18:01 And then they're debating two different stories, and one is actually talking about the FC and one is the EC, and one is debating the niche. And you can have all these different perspectives and they don't have a common Rosetta Stone to actually come together. And some people are just talking about what happens in principle with no reference to a data set. Someone else is talking about an empirical correlation to coefficient from a specific data set. So yes, Steven, then Bleu.

1:18:32 Stephen:
This is very helpful to map it out like this. And it sort of gives a sense of this journey of functional connectivity function to effective. And I'm wondering whether the process chaos evolved even further to effective connectivity in the sense of like Alice could ring up Bob and say, hey Bob, I'm feeling good tonight, so we're in a great day. Okay. Bob's like, okay, I'm feeling good.

1:19:08 Hey, I'm going to brush my teeth and I'm a bit more motivated to be into that big book that I really wasn't so interested in before, but I know Alice likes. Is that kind of extension something that's almost could be charted here from functional to effective to effective?

1:19:36 Daniel:
So it's a good question. We can imagine this little variable because again, we're not in the territory, we're on the map. If this variable is Bob's affect and Bob's affect has an edge that is influencing how likely Bob is to undertake the policy selection of calling Alice, then yes, there is an effective edge or a connectivity between the variable corresponding to Bob's affect and then the policy of what to say and then continue onwards. But not every single piece is explored here. But yes, affect can enter the picture and that's what's so fun and exciting about these incredibly composable and flexible models like active

inference.

1:20:31 So Stephen at then? Bleu and this also sort of harken back to that earlier question about social sciences and other sciences. This actually does provide a useful way to have a construct to look even at arts and the sort of relationship people be having. So as you may be thinking about as people think about narratives and stories, as well as, okay, what is explicitly happening and measurable through modeling what kinds of relational dynamics might be at play and that itself could be a useful boundary object in constructing cocreation work because you start to get some sort of framework again, provided you get some of the minimal constructs clear so that it doesn't just become noise.

1:21:31 Base. Bleu. So I'm also wondering about the relationship between functional connectivity and effective connectivity and just really I think about this always in relation to gene expression, right? So we observe a functional connectivity because two genes are expressed in the same tissue at the same time. They're both up regulated, right?

1:21:56 Bleu:
So this is something that Daniel and I have studied and maybe foreign to the rest of you guys. But effective connectivity also in terms of gene expression is like there's a downstream effector molecule, right? So there's a molecule that has an effect downstream of the gene expression. So like there's one transcription factor that diffuses through a tissue and then active the transcription of something else, right?

1:22:25 So it's not that I think functional connectivity and effective connectivity can occupy the same space at the same time, but what is it then when there's effective connectivity? Like I am the transcription factor, so I'm effectively connected to downstream genes, right? And so when I activate two genes at the same time, are those effectively connected to the transcription factor but functionally connected to each other? Like I wonder just if there's any degree of overlap between functional connectivity and effective connectivity. Thanks, Dean.

1:23:01 Dean:
Can I ask you a question? Bleu because I know nothing about jeans other than I wear them occasionally. Do genes automatically go to the place of affording us certain things as an effect or can genes be an affordance as a cause? Because it sounds to me, knowing nothing about genes that you're describing, that you're saying that genes can also be a cause, which I think would be really interesting, but I'm not sure if that's I don't know is gene only an effector or is gene also an affordance around cause? So Ines can be causes, especially genes like transcription factors.

1:23:48 Bleu:
But I was mentioning earlier, a transcription factor just like activates the transcription of other genes. That's what its job is. And it's something that happens like very normally during the processes of development and the transcription factors diffuse along axes and then it causes like a cascade of developmental gene expression timing that happens. So if it could be both a cause and effect, are you saying that whether we measure it traditionally with a timestamp that in effect has a built in affordance for time? It sounds fascinating if it's true because I said I don't know anything about this.

1:24:32 Dean:
But if that's the case, maybe some of the traditional ways that we measure change have to be reviewed.

1:24:43 Bleu:

Right? Let me see if I can understand your question fully. So in the process of development, there are specific genes that are expressed in specific issues at specific times that aren't expressed any other time. So in that way, I guess mark time. Is that kind of what you're asking?

1:25:02 Dean:
Yeah. Yes. Genes as kairos is a very interesting idea. Like there are certain critical periods where developmental factors are expressed in sequence. But let me also respond to the comment about what Bleu said about genetics.

1:25:18 Daniel:
So unsurprisingly genetics uses a different ontology. They use a different on Ft actually ontology narrative, formal documents and tools than neuroscience. So when people in genetics are describing functional connectivity or functional interactions, cell those connectivity, usually for cellular biologists, function is equivalent to mechanism. And so a functional connection would be like a mechanistic physical linkage. So two proteins that bind, that's called a protein protein interaction or like DNA protein binding, like the transcription factor example that Bleu mentioned.

1:25:57 So that is often what is meant by functional connectivity. Effective connectivity I don't think is used that much, but if it were, it would be used informally to describe the effect of one on another mechanistically, probably not in this time series perturbation framework. And this is one of the most fascinating areas. Like people talk about gene networks or gene regulatory networks, but there are multiple kinds of networks that you can make. You can make networks of proteins that bind to each other, you can make networks of proteins that are coexpressed.

1:26:42 So they have correlated expression patterns, which is functional connectivity. But that doesn't mean that they're functionally related. There could be one factor or cellular scenario that causes two genes to be upregulated so they're going to appear in the same coexpression group and therefore a neuroscientist would say that they're functionally connected. A biologist might jump to say there's a functional relationship or oh, there's a gene ontology enrichments of this coexpression module. So there's some sort of functional relationship, but it's being used in a slightly different way.

1:27:18 And wouldn't that be fun to have shared ontology for systems that ultimately are related, like agent expression and neurophysiology. So Bleu and then Stephen okay, let. Me just respond to that really quickly. Okay, so take my gene expression comment aside. Let's go back to the brain.

1:27:39 Bleu:
So say there are two neurons that light up at the same time. They're not connected, right? So that is a functional connection between those two neurons or brain regions, right? But let's just use neurons for the sake of simplicity. So two neurons that light up at the same time, they're functionally connected.

1:28:00 Now, one neuron that lights up and then touches another neuron and tells it to light up, that's an effective connection, is that correct? Yes. Or if you had a hidden third neuron with a time delay and it influence one in one time step, and it took two time steps to get to the second one, you would see an effective connection between the two that you measured because the second one would always get activated after the first one. And so that's the challenge with interpreting effective connectivity as a mechanistic story when actually a whole diversity of mechanisms can give rise to the observed empirical effective connectivity. Okay, but wait.

1:28:39

So here's my question. I'm trying to see if there's any overlap between this functional and effective connectivity. So say I have one neuron that touches two neurons and tells those two neurons to light up at exactly the same time. Is that effective connectivity between the original neuron and the two neurons that light up subsequently, and then functional connectivity only between those two neurons that light up at the same time but are not touching. Is that correct?

1:29:06 To think of it that way, yes. The two children would have functional connectivity because they have a temporal correlation between remote events. However, they would not have an effective connectivity because activity in one would be conditionally independent upon activity in the other. And then from the point of view of that parent neuron, it would not have functional connectivity because let's just assume that it spikes and then the next time step, it's not spiking in the children are. So it wouldn't have a temporal correlation in its activity at a lag of one.

1:29:39 Daniel:
It gets a little bit more complex when we're talking about time lag models, but it would have effective connectivity through time because it is like a directed edge influencing them. And functional and effective are independent of the anatomical connectivity, which is what you'd find out with a microscope without taking any measurements. So there's no overlap between these two categories. There are situations where they can be high for both or they can be low for both. And there can be anatomical connectivity and functional or effective or any combination.

1:30:16 It's like for two nodes, there's like a tuple of how strong that edge is functionally, effectively and anatomically. And it could be one, one one. It could be negative one, one negative one. It could be anything so I'm trying. To think of a circumstance where something can be functionally and effectively connected.

1:30:37 Bleu:
How is that possible? So there would be like two cryptocurrencies who over the year time scale have both gone up. So at the course graining they have a positive correlation that's the functional connectivity. And they have a day to day correlation in their movements such that one moving leads the other that day. So then they have ineffective connectivity on the short time scale because through time, changes in one caused the same direction of changes in the other.

1:31:11 Daniel:
And when you zoom out, they have a broad scale correlation.

1:31:18 Bleu:
Got it. So depending on the time scale, they can be functional or effective. Yes. And this is like where it does matter exactly how there's not just one way to do a time series correlation because a time series correlation can be just like an Arima model can have different time horizons. So one can look at the temporal correlation like, let's just say you had two out of phase oscillators.

1:31:47 Daniel:
If you had a time horizon of one, they would have very strong negative correlation. But if you had very, very long time windows, they would have about the same average. So you'd think that they were uncorrelated, for example. So time series correlations extremely depend on the specifics of how it's calculated. Which brings us back to model based science and you know, a w for the instrumentalists over the realists.

1:32:14 And that's why Beni is saying like, yeah, don't get too concerned about whether we're finding cycle or directed acyclic models because those are just modeling conveniences that are downstream of the experimental setup and the measurements and the quantification techniques. So let's focus on that. And we'll see that we're engaged in different flavors of the scientific endeavor and ones that include humans and all the ways that they work. And that just trying to look at that distilled kernel of like, well, the coefficient is .7. So it's a module that is a metaphysical conclusion or an ontological conclusion being drawn from a methodological process that might be unwarranted.

1:33:17 So in our oh yes, Steven, go for it. Yeah. So if we were to take between these two, I think this has really helped clarify because I think you're right, these words are possibly open to some confusion at first. If we were to take brain scanning, which is essentially you can have electrical signals which agent very easy to identify where they're coming from, that you can get a good sense of temporal fidelity and then you've got fMRI, which tends to be a bit more over time. Friston has been bringing that to the table.

1:34:01 Stephen:
The idea that what's the more general function at play and what's the type of spatially understood changes happening over that temporal depth, whereas the effective connectivity might be more like, what can we effectively say, changes between this and this for a more specific, definitive time scale? Would that be one way that you're talking about the methods influencing which types of models are relevant that would tie into that? Yes. Awesome point about sensor fusion as well as the differences between fMRI and M and EEG. So EEG is on the surface of the scalp, although you can also take electrical measurements within the scalp.

1:35:04 Daniel:
It's on the surface and it has extremely fast temporal evolution, like many, many times per second. And it's localized and it's measuring electromagnetic activity. fMRI has a very different spatial and temporal resolution and it's measuring something different, which is the blood oxygenation independent signal inside of the brain, which is related to the dynamics and the metabolic activity of brain regions and the vasculature. So they're measuring different things. That's why it's so important that in active style models that we clarify what our observations are and what the hidden states are that we're doing inference on.

1:35:50 And so one of the ways that sensor fusion happens in SPM so what's being described here as multimodal integration of the EEG and the fMRI is there's a latent unobserved variable, which is the neuronal activity. And then that neuronal activity at a given voxel is going to have an edge that outputs fMRI measurements and then another edge that measures EEG outcomes. And then what's happening with that unobserved variable is being fit based upon the jointly measured fMRI and EEG. So it's not just like you take a big time series and do descriptive statistics, but rather you use this hidden states and that s what allows the generative modeling of brain activity because you're fitting the hidden states which gives rise to observations which can be of totally different types. So it is an awesome thing to explore.

1:37:00 I hope we can continue to delve into this type of like sensor fusion and what these Bayesian hierarchical model actually enable. Dean and then Stephen, I'm trying to. See if I can come up with ways of being able to sort of keep the effective connectivity and functional connectivity segregated before they're reintegrated. I don't know whether if we were to find ourselves out in the middle of the wilderness and come upon an anthill, and suddenly out of the anthill poured a bunch of elephants the size of ants, whether we would need to look at the mechanics of that or we would just be drawn into the

idea that now there's these really what was surprising and essentially ant sized elephants. Or if we saw elephants suddenly walking or ambling as though they're still the normal sized elephants, but petting as though they were ants.

1:37:58 Dean:
So taking the tiniest of footsteps relative to their overall scale, I think that's where the effective connectivity and active inference based on some of it based on priors, but essentially I want to keep the Dutch of the effective apart. Not that they can't overlap or that our minds aren't able to make those connections, but I think each serves a purpose so that when we come up against surprising, we know kind of what went into that moment or that event.

1:38:35 Daniel:
I'm kind of seeing the size of the animal as the year performance of the crypto and then the DayToday is the effective connectivity with the footsteps. Yeah, the scale all I was trying the scale and relativity as opposed to the sequels. Interesting, Stephen. And then there's a question in live chat. I'm going to ask a little question with this.

1:38:59 Stephen:
Again, maybe rhetorical over the timescale of this effective connectivity. It can effectively be brainbound to some extent when we have functional connectivity.

1:39:25 The measure or the unit of analysis is implying something outside as being connected to that or something that's a slightly more macro I the idea of the function that's being used as a unit of analysis to then give away to get purchase on temporal correlations. Would that seem to be fair enough? And would that also possibly also then reflect the sort of journey that's happened in cognitive neuroscience and computational neuroscience because of Bristol's work? It started to that even in itself brought in this process of cell. What does it mean to have function?

1:40:17 Daniel:
Again, we want to be precise about what function means here. If the measurements are all brain related, then that's the nodes corresponding to the variables that edges are going to be calculated within. If there are measurements that are outside of the brain, then you can have functional or effective connectivity amongst those variables. But we're not actually talking about function like mechanistic impact nor teleological impact in the niche, which is like the function of the hammer is to nail things. That's not what functional is meaning here.

1:40:51 And just to give an example of this is the awesome recent work by Guillaume Duma and collaborators. And so this is a toolkit that expands on this neuroimaging framework and just says, well, we're just going to concatenate those matrices. Kind of reminds us of the Stochastic chaos Paper 32, right? Like when we went from having one coupled system to having the two coupled systems. And then remember in the off diagonals, we had the effect of the two different systems on each other, the causal impact of the systems on each other, the effective connectivity of those systems.

1:41:31 And so this is hyper scanning where you have two people, or it could be a human in a computer, whatever it is, whatever the measurements you're making are the rows and columns on this matrix. And then you have that matrix, the measurements at each time slice going through time, it's a tensor. And then you do time series statistics on that tensor. And so these connections between the two brains are not anatomical people's. Brains are not actually wired up that way.

1:42:01 However, you could calculate the functional connectivity, which is not the function of one on the other, it's the temporal correlation between the events. And you could also calculate the effective connectivity which is what is the statistical impact of one variable on another through time? Whether or not that's the mechanistic link is a separate question. And that is what was revealed with this example was even if you hyper scan those people's brains and you say, I mean, come on, this brain region always leads this other brain region in the other person. But that doesn't mean that's the mechanistic connector, it just means that it's an effective connective edge.

1:42:42 And so this toolkit and this hyper scanning approach like really demonstrate that you can have functional and effective connectivity amongst any variables that are being measured in your experiment. But that's not the same thing as a mechanistic story about what's happening. Stephen.

1:43:03 Stephen:
Okay, just one thing to clarify. So is that bottom diagram saying that there's both fMRI and EEC? There's electrical and blood flow measurements happening and they've been integrated, this one. So in this paper, that was the sensor fusion. That was the interactions of multiple neuroimaging modalities fMRI and EEG.

1:43:30 Daniel:
Here you could do sensor fusion, hyper scanning, or you could just have EEG on each person, or you could have EEG on one person and fMRI on the other. You'd have to qualify what it is that you were actually measuring. But this is a general framework for multi agent neuro imaging statistics. Okay, perfect. So then the point I was thinking that sort of relates is I think this is really useful points that you say about how it's not function in some sort of ecological sense, however sort of hidden in the linguistic couching that's going on here for it to be viable, okay, not necessarily for it to be experimentally.

1:44:18 Stephen:
How it's done is implicitly. The effective connectivity seems to be couched on or there to be something meaningful happening or some sort of process happening. Effectively a one year old has to exert something or potentially have some direct effect. It's like a contingency that is present functionally. It's like, okay, within whatever function going on, but we don't necessarily know what that is.

1:45:00 But within some sort of process.

1:45:04 Bleu:
There. Is something happening that we can infer, is useful, is coming into play. We're not saying because we know they're spatially separated, we can't say for sure then, or they're temporarily hard, too fuzzy, we can't necessarily say they leave to be connecting. But functionally we're getting a feel for that this dynamics is present rather than this almost more signal based approach. If there was more effective and I think that that is philosophically couched in those two words.

1:45:57 Daniel:
Yes, I totally hear you.

1:46:03 The mathematical and the statistical distinctions are the ones that are being calculated. So trying to read a lot into the English word and then apply that reading in to the calculation is where we get a little lost because again, the effective connectivity, it doesn't mean that there's a mechanistic relationship. You could have spatially remote neurons that have an effective connectivity edge like the example we discussed earlier, where there's a causal neuron and then it takes one time step to get to this

one and two to get to the other. So then those two recipient neurons are going to have an effective connectivity edge. It's a hypothesis whether there's a mechanistic edge, but that's something that you can explore with science, is you can actually look at whether then you test, well, what happens if I evidence this one?

1:46:54 You go, wow, the firing pattern didn't change, so I falsified or reduced the posterior likelihood of a mechanistic story that involved a mechanistic edge. It doesn't invalidate the measurement of an effective connectivity. It just means that you have to look elsewhere for your mechanistic story. You shut down Bob's phone and there still is this effective connection between the brushing the teeth and the reading. Well, now you look back in the system.

1:47:22 Iterated scientific modeling. So I just want to ask this question from the chat. This will be our last question and final thoughts, but very fun and interesting, and I hope next week madib will join and that will be great to hear his perspective as well. So Joseph Clark in the chat asked, how do you utilize functional and effective connectivity in active inference analysis to better inform an answer to a question such as why I scored the goal? How does enrich and analysis so, Dean.

1:48:13 Dean:
Yes, something I would need time to think about that question. So maybe that's something I can think about and point to because right now I'm trying to figure out if a gene is both a cause and an effect, how is that then going to be encapsulated and partitioned? Because basically blew up my DAG and I'm going to need to go away and rest for a little while and think about this, because if it's both, is there information just encapsulated? Is it information partially encapsulated? Because now it's a whole bunch of genes that are dealing with their between this and all of that good stuff.

1:48:53 But again, my final thought on this paper is that I think whether we keep it on the abstract level of something or partial or whether we pull it down as he does in the paper, to the actual moment of we're looking at something now in particular. Now I've got to sort of go and take that off to the level of genes and see whether or not that changes exactly. It flipped my Dutch rabbit on it. I'm rolling downhill here. I need to take a break.

1:49:30 Daniel:
I agree. I think this is an excellent question because effective and functional connectivity, you'll find like tens of thousands of citations in the neurosciences and you'll find people talking about the applications and translational value of neuroimaging towards real life settings. I'm sure there's even neuroscience of football or of soccer. So how do we actually connect all those dots and describe how specifically within an active inference framework how do we think about these different kinds of modularity functional, the effective, the anatomical, the informational? How is that related to Markov blankets?

1:50:13 What's unique about the framing in active inference compared to the neuroimaging that has existed for 40 years now? Much of it was also developed by Friston, but still there's more to it. So I think these are great things. So one thing that we know will discuss is that question how do we deploy functional and effective connectivity so that we can get better answers? We also want to talk about modularity intransitivity and preferences.

1:50:45 Steven and then any other last thoughts? What are you excited to discuss next week? Yeah, I think this is a good question to end and also start the next one. I suppose one thing this idea of this is useful is ideas of how certain types of effective connectivity was important for scoring a goal. Like

what was tethered to what in terms of the connectivity and where are we talking about something where what's the dynamics system, the generative type of system where that involves making it happen?

1:51:33 Stephen:
I get a sense that the functional approach is more connected to dynamical systems thinking and in comparison to the effective approach, which might be more related to how things are potentially wired up and what's first order, second order, third order affect. I don't know if other people see the same, but it's helping me. This is really useful for me starting to think, okay, I see where Friston was sort of coming in with this question of how to address these hidden states, these hidden dynamics, these hidden causes, and how by coming in it through this functional dynamic or inference approach.

1:52:29 Daniel:
You. Could say it changes everything in some ways. So it certainly means that you have to have more than one way to understand the hidden states, which is also like how the footballers also got more than one way of trying to understand what it even means to score the appropriations, being mixed with visual, being mixed with auditory, being mixed with tactile. All these things are some things do need to effectively happen. Certain muscles need to happen in a certain order.

1:53:01 Stephen:
A certain coordinated action has to effectively happen for it to even be possible. But there might be multiple dynamical functional ways that I could also bring purchased and have different ways to get to the same result. And again, it becomes relevant when you're trying to do the type of measurements that have been designed for a particular reason so that you're not going to try and get at the store temporal inferences through using fMRI and vice versa. So I think that's something
that's quite useful. Great.

1:53:48 Daniel:
My closing thought will be studying the footballer is our football as researchers of football.

1:54:00 Thanks, Dave. Dean Steven, Bleu and fun to participate today. And thanks a lot, Majid, for writing this provocative paper and getting our 22 off on a good. Foot in act in flow. So thanks, everybody, for listening.

1:54:19 Please get involved. Come join us next week. Or a future week, if you'd like. And until next time.

Session 035.2. January 12, 2022

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

Second participatory group discussion on the 2921 paper “A tale of two architectures free energy, its models, and modularity” by Majid Beni.

SESSION SPEAKERS

Daniel Ari Friedman, Bleu Knight, Majid Beni, Dean Tickles

CONTENTS

TRANSCRIPT

00:22 DANIEL FRIEDMAN:
Hello and welcome everyone. It is January 12, 2022. We are here in ActInf Lab livestream number 35.2, discussing the paper. A tale of two architectures free energy, its models and modularity. Welcome to the ActInf lab.

00:42 We are an online participatory lab that is communicating, learning, and practicing applied active inference. You can find more information on this slide. This is a recorded and archived livestream, so please provide us with feedback so that we can improve our work. If you're watching Live, feel free to write questions in the live chat. If you're watching in Replay, you can also add comments.

01:05 All backgrounds and perspectives are welcome here and will be following good video etiquette for live streams. All of our activities in the lab are participatory, so if you would like to contribute or get involved, go active inference.org and see what is there today in livestream 35 two. We're going to be having our third discussion continuing on the paper, A Tale of Two Architectures Free Energy, its Models and Modularity, written by Majid Beni, who we're really appreciative, is joining us today to talk and see where it goes. So we'll get to the introduction in a second, but basically we're going to just pick up on some of the threads that we opened in earlier discussions. We have a few specific things written down and I'm sure we'll go many different ways with people joining and ideas coming up and questions in the live chat and all of that.

02:05 So we can kind of go any which way, but we'll just start with the introduction and warm up so we can each say hello. Maybe Bleu and I can just say what we're excited about for the dot two and then vegeta it'd be awesome to hear any context for the paper. So I'm Daniel, I'm a researcher in California, and I didn't expect the Rabbit duck to appear in dot one, but I'm looking forward to continuing that and seeing how is this drawing like a scientific model and then what does that philosophical or conceptual paradox or ambiguity say about scientific modeling? So Bleu.

02:51 BLEU KNIGHT:
I'm Bleu. I'm a researcher in New Mexico, and I am excited to probe deeper into the relationship between agents and their environment and also the intransitivity argument and modularity and how those kind of all fit together.

03:10 Daniel:
Excellent. Majid?

03:14 You are muted and then please continue.

03:19 MAJID BENI:
So, hello. You can't hear me? No? I'm Majid. I'm an assistant professor of philosophy at Mid to Middle Technical University, and I'm obsessed with models and structures across science and perception and mind. And it's for a while that I'm engaged with this issue of applying model based approach to science to free energy principle and predictive coding.

03:46 And I'm very happy to be here. Thank you very much for inviting me. Great. Well, maybe just for background and context, what brought you to write this specific paper, like recognizing modularity as an important topic, and where does this fit into some of your other threads related to FEP and model

based science?

04:16 That's a very good question. I'm not quite sure why one reason for focusing on modularity in this paper is that most probably it has some sort of psychological explanation because I started to learn about philosophy of mind and philosophy of cognition science by reading this language of thought. And I think that even in the earlier stages when people were studying there, no one was thinking that the brain is actually a syntactical engine. No one was thinking that if you open up a brain or a cognitive system you actually find things that are inside the brain in terms of propositional like entities, language like entities or syntactical engines or anything of that sort. But at the same time people were believing that that perspective on how the brain works have some sort of explanatory gain.

05:16 There is something that we can learn by taking that perspective on the brain and collective system. Well, I think that the general idea behind applying this model based approach to sciences is that it is the explanatory interest, explanatory as well as practical interests of the modeler of the people who are engaged with scientific enterprise that provides a handle on the target system, the things that we try to explore and understand.

05:53 I think that when I was reading the target paper by Kirchhoff Ines Hipolito Cell, what struck me as odd was that they were taking it very much for granted through, of course through very well articulated scientific and philosophical arguments that there is no such modularity inside the brain or cognition system. And I just wanted to bring the point to attention that it would be a matter of, as I said earlier, practical and explanatory goals and interests of the modeler, whether there is modularity there or not. So one thing that I'm going to emphasize underline in this session is that it doesn't need to this model relativity doesn't need to lead to downright anterialism about theories of brain and cognitive system. Model activity is not all about taking an unrealistic attitude to our brain science but at the same time the old goal, the old project is to end up with some sort of subtler perspective on scientific reality about cognitive science and the brain science.

07:29 Daniel:
Thank you for the context. Welcome Dean if you'd like to say hello and if you have any opening shots to fire. I don't have any opening shots to fire. My name is Dean, I'm in Calgary. I'm sorry for coming in late but my link was sending me off into another corner of the universe.

07:54 DEAN TICKLES:
So glad I'm here. Thanks for thanks for being here mjit I'm really glad that you're here to talk about this paper. I found the paper fantastic. Pleasure is all mine.

08:12 Daniel:
Modularity, I mean it's in the title modularity models and then the free energy and then the tail of brain architectures which was a little bit of a reference towards the tail of two densities another active paper. So just how would you reframe the argument of Hipolito and Kirchhoff Majid? And where do you think, like in 22 what can we say now that we couldn't have said in.

08:53 Majid:
Well, I do not think that we could say anything more than we were saying in 2019 because all of the actual stuff was there. I think that this is something that comes with philosophy because no information has been added. As a matter of fact, I just elaborated on the information that was there in terms of the argument from intransitivity and all of that discussion of causal modeling and dynamics modeling and all that. So I don't think that any actual information has been added. The only thing that has been

elaborated on was the emphasis on the rule of the modeler.

09:42 I was watching this in the previous discussion of the same paper in active inference lab Dean's discussion in terms of the Bob align metaphor, the discussion of the perspective of the observer, the observer that is watching both Bob and Alice interested me very much. So if I want to rephrase the discussion of the modeler in terms of information here we can start real estate as in terms of the observer. But I don't think that the point is that technical the point is rather philosophical than scientific or formal in terms of information theory. So no actual information has been added during these two years and I think that this approach is gaining momentum. This emphasize on the rule of modeler or interpretation is learning to even more discussions in the free energy principle literature.

10:51 Daniel:
I totally agree with that point. And then blur. Dean it made me think of Quantum and how the double slit experiment kind of kicking and screaming has taken 100 years in that one limited setting to consider the role of the observer. Even though it's really a complex thing. We won't go into it.

11:15 But we'll talk about Quantum and FEP in a few weeks. But that was like the anomaly that signaled yeah, you need to take the observer into account. Hae park of the measuring apparatus very quantitative empirical observation that there was a nonnegotiable or irreducible role of the observer. And then on the qualitative side, the relational insight that scientists are human and science is a human activity. And that was not driven on empirical observations of wave and particle on a screen like the twin slit was.

11:58 But it was just a sort of low level philosophical argument that there isn't a fungible role for the observer or the modeler. And so it is very interesting to see how that has started to catch on and then how does that change the way we do science when that is taken as like a starting point that there's an observer modeling the system? So like that was in this diagram when we started with just talking about the functional and the effective connectivity and then the mechanism which is kind of not either those and then it wasn't until the very end when we're like, oh, but it's the scientist projecting in to this whole model. That's another level of how we think about it. We can't just like all be sitting around just talking about Bob and Alice.

12:58 But then now there's going to be us with multiple perspectives, looking at the scientists taking multiple perspectives on Bob and Alice. So are we stuck in this sort of subjective, infinite regress? How are we going to salvage cognitive realism?

13:22 Majid:
Are you asking me? Anyone?

13:28 Daniel:
But if you have any thoughts, definitely go for it.

13:37 Majid:
I have some ideas, but I prefer other.

13:45 Daniel:
How about Dean and then Majida, then Bleu if you want to. Well, one of the things Majid that I took away from reading your paper was this is funny because typically when I pick something up, it's pretty foreign to me. It starts out being way on the other side of a Markov

blanket. And then I guess I somehow I'm able to sort of get inside of it and relate it back to the things that I know, and eventually, I get a bit of a grip on it, and then next thing you know, there's four duck rabbits spinning madly out of control on on a gradient. But one of the things that I took away from this was, and I think I mentioned it in the .1, is are you 09:00 in when we're taking these slices in time and we're building these models?

14:44 Dean:
My question was, what are the specifics of that? I mean, if we take an fMRI imaging, I know that the machine itself that's taking those slices of time isn't necessarily conscious, but it is carrying out some sort of an instantiation exercise. And so one of the things I wanted to kind of talk to you a little bit about, not necessarily on a quantum level, but one of the sections of your paper which was really, really influence to me was a action on a golden thread. I was hoping that perhaps within that idea of partitioning, whether it's through quantum quantum methodology or quantum series or whatever, if you COVID maybe talk a little bit about that idea of what you meant by a golden thread not just metaphorically, but maybe materially and maybe influentially, if there is such a word. Because that part of it really mattered to me and it actually got me writing a whole set of sub notes based on that action.

15:52 So maybe you could expand on that a little bit because I think there's a lot there. Thanks Steam, for the great question. So, yes, we'd love to learn more about the golden thread on mute and then continue. I told that very well. So if I may do a bit of advertisements, I have been discussing this specific issue, this dog rabbit thing in another paper, which is published in a philosophy journal.

16:28 Majid:
It is named cognitive Penetration and Cognition Realism. And this is published in Episodes. It relates this issue to the issue of theorylatedness in philosophy of science, works of Thomas Kune and all that what I say here. I'm also interested in the relation between feb and quantum theory and I'm working on a project that relates Pheps to cubism as one of the significant interpretations of quantum mechanics. But in this context the paper is not directly related or even indirectly to quantum mechanics.

17:14 And the rule of observer. I rather take some sort of so if I want to say this in more technical terms, I would use Shannon's theory of information to articulate the rule of the observer. A bit clearer about the question, if I understand it correctly, what happens when the picture rotates and there's a scanning of some sort of scanning is taking place?

17:50 Am I correct to understand that your question is about what happens when there is a rotation but there is no observer to want to work, whether it is a dog or a rabbit, right? Yeah. And the whole business of so when we're trying to encapsulate something and you spoke clearly in the paper about we don't necessarily have to see this as a hard and fast edges kind of thing, we can kind of appreciate that there's a certain amount of fuzziness that's actually enabling our conversation. And so that because the lines aren't abrupt and when we do decide to put a Markov blanket around something, it's us choosing to do that at a certain scale with a certain amount of specificity. And Stephen Sillad in The Zero One talked about so what is available at a meso scale?

18:45 Dean:
So that golden thread business that what do we last cue? What is that fMRI actually trying to entail? That's what I was hoping that maybe tease out for us a little bit. Very well, I can be all clear about that because being a philosopher, I'm a bit naive about neuroimaging and that sort of stuff. But as some sort of general insight and trivial insight from philosophy of science, I would say that it would depend on what we are trying to trace by using fMRI or any other observational device or measurement and the

fact that we could use this measurement devices in a number of different ways.

19:27 Majid:
And by devices I do not only refer to actual devices but also entorhinal devices such as Markov blankets and that sort of stuff. And applying that to different scales and different levels doesn't need to mean that there is no objective fact of matter to be represented by these devices. I might be able to use different vertical and mathematical devices to measure the space of my room. I may be able to use, for example, kilometers, or I may be able to use wet noodles or something of that sort. And this doesn't mean that there is no fact of matter to be measured.

20:12 After all, we can see this picture in terms of either rabbit or a DAG, but not as a dog or a goal for examples. And whether we see it as a dog or rabbit, again, is influenced by so. I would say that to some extent it will depend on the original vagueness of the picture. To what extent the subjectivity, to what extent can affect the perception of what we see is a matter of the target system itself, the properties of the target system itself. No matter how hard we try, we could hardly be able to see this dog or rabbit as a co or a dog or something else, but at the same time, to some extent, especially when the target system allows for some vagueness to some extent or pressuppositions or goals and intentions beyond the actual situation.

21:09 And so there is some sort of constraint or moderate amount of theory relatedness to use the jargon by philosophers of science that is taking place here. But it doesn't mean that there is no I mean, it doesn't need to strip the targets of all of its objective features.

21:39 I'm still not sure whether I could address your worry correctly or not because I couldn't see the point about the fMRI and neuroimaging techniques. So.

21:52 Dean:
I guess I'm kind of agreeing with the argument that you were putting forward, which is that anytime we make an observation and then we draw up some kind of a representation, we call that a model. Even in those efforts to try to be precise, we have to leave open a little bit of latitude, a little bit of wiggle room because as you pointed out, you can have a dynamics causal model and get into an argument of whether or not that's the appropriate model that should be an acyclic one, for example. That was what you were saying. And that kind of gets you going down a path of arguing about which is the right tool as opposed to saying do tools leverage right? I think that's what maybe that's what I was reading into what you were trying to say.

22:46 That's all.

22:49 Daniel:
Thanks, Dean. Bleu and then magic. So I think this kind of goes into what Dean was saying about scale friendly versus scale free. And so like with a Markov blanket and with like this denotation of a module, whether it's vertical or horizontal or vertical module, we impute the Markov blanket on whatever scale we're trying to separate conditionally. So I just wanted to bring that point back in.

23:28 Bleu:
And also this idea of maybe like incomplete partitioning. So I mean, if there was a complete partition around each module, there would be like no ability to transfer information from module to module. And in the brain we do know that definitely the pieces have to communicate to make the entire brain or it wouldn't be considered an organ, we wouldn't be able to mark up blanket. This idea of nested markup

blanket. So I don't know about this information encapsulation or information leakiness Majida would be nice if you maybe kind of unpack that a little bit more for us.

24:16 Daniel:
Yes, the information encapsulation topic.

24:30 Majid:
So the thing is that I can't see for some reason I can't see you in this picture and I have to shift to the YouTube page in order to see you can maybe go. To on the bottom bar toggle tile. View there's like I use that but it's all right. It's for some reason I can't see that there are pages of people but I cannot just see your faces. It shows the initial D and D and B.

25:01 Daniel:
It may have to do with what controls were all in, which is totally fine. At least we have audio. Let me try it once more. Yes, at least we have audio.

25:17 Majid:
Cell evolved information correlation. Shall I explain that in terms of that Bob Alice metaphor? Great.

25:29 Daniel:
Yeah. Information encapsulation as applied to the Bob align parable. All right. Terrible. So for one thing, this information encapsulation is one of the features of Jerry Folder's original statement of the thesis of modularity which is quite flexible testis and motives.

25:55 Majid:
So for me in the way that I see that model relativity entails this kind of modularity information encapsulation because in order to have model again, it can be stated in terms of learning blanket states whether the mark of blankets are embodied or nested or not is itself another issue. But the very fact that we can use Markov blanket or Markovian models, it indicates that we are able to set some sort of barriers, conditional independence between internal and external states. So in order to state this free energy principle christian there's interpretation these spaces in terms of active states and sensory spaces but at the same time it indicates that there is some sort of barrier even though it's the barrier is cognition and probabilistic. And I do not think that for information encapsulation there's anything stronger than this kind of flexible conditional barrier between inside and outside or between different spaces. And this is the point that so when I was watching your discussion in the previous session zero three 5.1, I saw that this metaphor of Bob and all this Lamme out and there was the question of whether there is any sort of causal correlation between them and whether the relation between them is any way correlation.

27:25 So as I argued in the paper,
there may be some sort of causal relation or correlation which can be stated in terms of interventionist approaches which are of course liable to their own other source of criticism that you do not need to discuss rights though. But I think that information encapsulation doesn't need anything stronger than the general model activity that I tried to advocate in this paper. So the main point is that regardless of whether or not there is any kind of causal correlation actual relationship between the actions of Bob and the actions of Align, or perhaps I have to call them Charles and Lucy in order to be more loyal to the soul of the table of two cities. The thing is that to the extent that the information in each unit is not available accessible to the other unit we can speak of information encapsulation. And when we are making models, if we can't set any kind of distinction between internal and external spaces.

28:38 And if we kant in the same way that we may not be able to set a distinction between models and their targets, there wouldn't be any modeling practice, there wouldn't be any scientific activity. On the other hand, if we are able to set a distinction between internal and external or any kind of distinction between models and their target, we would be able to estate some sort of conditional barrier. It still doesn't indicate that there is no kind of information.

29:14 So setting the barrier by itself doesn't show that the information in one block is not available to the other. Black but I was fascinated by this picture when I was watching your discussion in the previous session. So in terms of the relationship between Bob and Alice, the action of Bob brushing the teeth is correlated with what Alice does in the other unit. But it has been assumed that the information in the unit is not available. The information in Bob unit is not available to Alice and vice versa.

29:52 Even though the information may be available to us as observers or if the control as an observer, a third person, the information might be available to her, to the observer. But to the extent that the information in each unit is not available to the person in the other units, I think that we can speak of some sort of Attial information encapsulation.

30:18 Daniel:
Thanks. Very interesting. I just really caught on that part about how if we couldn't make a distinction between the target system and the model, between the territory and the map, then it's not modeling. So it's kind of like, well, when you kick a football, does it model a parabola cell? It doesn't have the modeling, the self modeled integrated world model, whatever one wants to call it, such that it is just the actual causal relationships that it's engaging in the world and no more.

30:55 Whereas cognitive entities like scientists are engaging in modeling and then that means that they are able to engage in counterfactuals, in thinking through other minds. They are reducing their uncertainty from. A. Partial information encapsulation view. And sometimes you get more information than the system has available, but other times it's radically less.

31:34 And so it's kind of like an application of a Markov blanket partitioning with some non Markov concepts, from philosophy of science to the scientists investigating target systems, getting partial measurements. That's their observations coming in, and then they're updating their hidden states, inference about what they think is happening, the likelihood of different hypotheses, just like any active entity would.

32:07 Majid:
Well, if I may elaborate a bit more on this and it returns to the function of cognitive realism. I think that despite speaking of all of this model activity it doesn't need to to be some sort of global or general form of anterialism because part of my activity in the past years was dedicated to developing some sort of cognition realism that is based on theft. Assuming that the practice of scientific model making is underpinned by the dynamics interaction between scientists or groups of scientists and their environment. So this kind of model activity, the relation between free energy principle and model based science is very complicated and it is not something that is directly related to this aspect of this paper. But this paper is a piece of a larger project that has been finding its own shape in the past few years.

33:07 And it is about the as I say, the general idea here is that in the same even though the free energy principle theoretical framework, experimental activity that is embodied in the research stream that leads to the development of free free energy principle. Basically some sort of model based scientific activity.

On the other hand, if you are interested in explaining scientific activity and scientific model making. And if we are naturalist, we are interested in finding good natural explanations for that. We have to look into the underpinning natural mechanism that makes scientific model making possible.

33:45 Right? And a good place to look for that is the scientific accounts of the interaction between the agent, the organism and the environment. Because Free Energy principle provides a viable account of the relation between agents. Or, as I discussed in my more recent work, a group of agents, which is the community of scientists and their environment, both social environment and biological environment. They can as well grown scientific model making in the mechanisms of free free energy principle.

34:14 The so the situation is quite complicated and runs in both direction.

34:23 Daniel:
We like running in both distinctions. So I guess that's okay. So we have a few different ways we could go Dean or Bleu. Do you want to ask a question? Or we can go to one that we've previously written down.

34:40 Dean:
Can I ask a quick question, Daniel? Yes. Yeah. So in the .1 Bleu brought up something that I'm still sort of trying to untangle when she was asking about genes in particular and how it might relate to what this paper was potentially pointing to. At least it raised the specter around the idea of information encapsulation.

35:10 Do we need time in order for us to be able to take a measure or put a boundary around or encapsulate or somehow mark in a Markovian way decide where the partition is? And so I'm still trying to figure out whether or not we are talking about a world where because I think a world exists where there are two things going Hinton not necessarily the same direction. We've got one thing where we look at the world and we ask ourselves whether something was completed. We do a completion analysis, we take an account and I think models fit nicely into that world. What I thought this paper raised some ideas around was that half of the whole picture is the other half.

36:06 Do models and being modular allow us to include or make sure that we have included everything that we need in order to be able to get the best sense of what's on the other side of that divide? So when we're making these inferences, we can use models as a way to account for things, but are we also able to project off of that and sort of make better guesses, better inferences? I've used the expression prediction matter expert. And so I was wondering again, those words weren't exactly used in this paper, but was that part of what we were trying to sort of dig down to is it is it just a matter of people use models? People's models account for things in certain ways, but they also, if we don't get too hung up on the precision of that account, they can also be sort of fuzzy and left semiopen and give us an opportunity to also be creative and decide essentially whether or not we have enough information to make that next best guess.

37:17 So I'm just kind of wondering about that.

37:22 Majid:
May I? Yes, please. All right. Very well. That's a very brilliant point.

37:29 So it comes back to the issue of competitiveness of models, their accuracy, certainty and that sort of stuff. And I completely agree it has been taken for granted and I think that part of this interest. Chaos

been Rise by Richard Levin's paper the strategy of model based evidence in population biology. We are making models, but the accuracy of models is very important. So the models have to be accurate enough to represent to do internal representation task well and they have to be complexity in the sense that they have to be detailed enough.

38:11 I think that this is a very good point, but look how much accuracy is enough. I mean, we Kant speak of completeness of models, but absolutely complexity models. I think that I've been reading a short story from a north and American writer on the executive of Science or something like that, which is the story of people in an empire who are trying model map makers, cartoographers who are trying to make maps of the empire and they are very obsessive. They want to have complete maps, but they end up with having maps that are oh, alright, perfect. Yes, yes, precisely.

38:52 So they end up with having maps that are as big as the empire itself.

38:59 And it's completely true that livings to speak of accuracy and detailedness of models, but then again, more details are not necessarily leading to better models. Because accuracy works only in combination with some other virtues such as generality and precision of prediction.

39:29 The other question is that how to find how to strike the right balance between generality on one hand and accuracy and precision of models on the other hand. And I'm tempted to say that I understand that I'm just trying to point to the same direction to speaking of the rule of models, scientific models and modelmaking. But then again, how much precision and accuracy have to be taken into account and have to be related to have to put in harmony with Geraldity? Again, I'm tempted to say that it is again a matter of interest and explanatory and predictive goal of the model maker.

40:17 Daniel:
So I will ask a question from the live chat from Stephen. So Stephen Majid was curious about your understanding of the relationship in which practitioners seek to apply low dimensional computational modeling with other scales of knowing in uncertain and dynamics environments. So for example, there's the awareness and the perception of the duck rabbit and then there are the affordance in our niche that go beyond just sort of a visual toy example. So open ended question about what you might think about that kind of application of modeling perhaps in a social setting.

41:11 Majid:
Do the models in the social settings need to be dimension? What if I see that in terms of the relation between dynamics causal models and DAG? So for example, I assume that DAG could provide some sort of low dimension model that is capable of representing the network aspects or something like that?

41:40 Daniel:
Yeah, I think that's a good question. I Dean continue with that and I'll write some things down. Alright, very well. So I'm tempted to repeat this. Well, I think that it provides a good example.

42:00 Majid:
So take the web of social correlation or social events that we may want to model. So this provides actually a good nice example of multi scale nature of target phenomena. So this the social events is constituted by the relationship between people and events and environment and cell. People are actually human beings, they are biological entities, constitute of people who are self organizing system and we are able to explain people and their behavior at some level on the basis of biological facts. So we may be able to use some sort of modeling system that are applicable in biology or that sort of stuff,

but at a larger scale.

43:00 When we try to model the relation between different people as nodes in networks and that sort of stuff, we may need to change our modeling device to I don't know, devices that are good at representing small board networks or that sort of stuff. If that does make any sense. I think that I just get confused by the point about low dimension of models in social systems.

43:31 Daniel:
It could be a Stephenism or one way at least that I would read that would be like the maps that we make are lower dimension than the territories. They have a different resolution, but also they don't consider they're not trying to be a full inventory of every variable in the system. Like, there might be a thousand chemicals circulating in our blood, but then somebody might make a lower dimensional model with just blood sugar or two dimension model with just Cortisol and blood sugar. And I think it's an active inference lab open question. When we make lower dimension models of complex multi scale target phenomena like you addressed, I mean, I don't want to jump to an answer, but it seems clear like, that the philosophical implications of a lower dimension map shouldn't be confused with a systems accounting of the territory because it's not the same thing.

44:42 And, yeah, Steven just followed up in the chat. He just said, generally, how does Majeed see the informational or physical sense of systems? Like, some people talk about systems in the more ontological sense about the parts and how they're connected. Other times, we're talking about systems informationally, like our analysis of the measurement data. And so the system, like the default mode network, is a connectivity pattern that isn't necessarily the anatomical connection.

45:12 So how do we think about these different kinds of systems? And maybe where does the FEP come into play with that? All right, very well. That's a very good question. So I'm a Tag, you're a structure realist.

45:26 Majid:
So I'm committed to some sort of information theoretic ontology, and I think that cell and I say that I'm defending some sort of embodied informational structural realism. So when I say that I was advocating cognitive realism, it could have been more precise to say that I'm advocating cognitive structural realism, which is actually the title of the book that I roll through this topic. And what rule free energy principle plays in this context is a very complex rule. So let's assume that we have the structure of scientific theories or scientific models on the one hand. So let's assume that you have a class of models or scientific models on the one hand.

46:11 And on the other hand, we have causal structure of the world, which is our target system, something that we are trying to represent by our scientific model. So when I speak about structural realism, I think that it has been the official wisdom of philosophy, of science for the past 15 years or so on. And people were trying to use different kind of formal vehicles such as set theory, model theory, category theory, to speak of this representational correlation between the class of models and the causal structure of the world. Right? So my belief with that was that the formal relations such as Isomorphism do not contribute to strengthening realism because these formal models, such as Isomorphism are not in force.

47:06 I mean, you can use Isomorphism to relate any two sets together, provided that they have enough number of set members. So it doesn't contribute to realism much. So what I was trying to do was to use fit free energy principle to account for the class of models and their target system in the world,

assuming that scientists are self organizing system that aim at minimizing the discrepancy between their models and their target system in the real world. But this is my take. I mean, it is something that I'm trying to develop.

47:45 I don't say that this is not the orthodox view either in the philosophy of science community or in the theft community. But I think that when we speak of representation in terms of the representational capacity of models, in terms of the relation between class of models and causal structure in the war, free energy principle can play a very subtle and a specific role there.

48:24 Daniel:
Maybe we're in a little strange neck of the woods, but I think having scientists as real entities doing something seems at home here. Bleu.

48:42 Bleu:
So I think you presented us with a lot of things that don't contribute to realism. But is there anything that you think does contribute to realism?

49:00 Majid:
Could you allow recipes because of the model activity or because of free free energy. Principle terms of cognition, structural realism? What does provide evidence for the cognitive structural realist argument? I mean, like you've given us a lot of things that you've deconstructed that. But can you take the opposite side and provide evidence for cognitive structural realism?

49:29 Or fair enough. Look, I think that the general arguments for scientific realism in general have been always estated in some sort of numerical arguments, assuming that if science was not representing the structure of reality, it would be a matter of implication. Adequacy of science has been a matter of cosmic coincidence. So there are some sort of arguments, usual arguments in the philosophy of science that try to relate empirical adequacy of science FICT theories to approximate truth of evidence FICT theories, right? And structural realism just tries to model internal representation correlation, the internal representation relations in terms of set theory and model theory.

50:26 So in my view, it would be more realistic to consider scientists as actual human being constituted by flesh and blood who aim at minimizing the discrepancy between their models and the world. I would say that the evidence that I could provide for this take on realism could be has its roots in evolutionary biology. Because if we had not been successful in minimizing the discrepancy between our models reality we would also fail to maximize our survey cell. I think that I can as a way of evidence or argument I can try to goal the argument, the usual scientific realist argument that aim to relate the empirical adequacy of science to truth of theory. I can try to relate or sexes to maximizing or survival as an evidence of or success in minimizing the discrepancy between our scientific models and their target system, the causal structure of reality.

51:41 Daniel:
Thanks. That also plays into some other discussions we've been having about like the objective function of science and the sort of multiscale nature that scientific fields, research labs and organizations and individuals are engaged in pragmatic and epistemic action. And so in active inference we have this scale friendly approach which a priori doesn't require a specific scale of analysis, which is what you brought up with Markov Blankets. And any specific application will entail a specific scale of analysis because it's empirical and so it's this 1ft in both world, just like linear models are, the model doesn't have a priori scale. But then when we specify it, we do make it specific.

52:32 And what's interesting about ActInf Lab that we could think about this action and perception loop of different kinds of nested entities. Now definitely it's going to get complex for any nested entity and then it brings a whole other level with a strange loop and the metamodelling and the cognizer and the thinking about oneself. That's like a whole nother level but just a way to talk about vertically and horizontally interacting systems is an awesome start. So Bleu and then either Majid, you could respond to what Bleu says or Dave, feel free to say hello. I just wanted to compliment you on that awesome prelude to next week's discussion about modeling ourselves.

53:18 Majid:
Right. So it's a very interesting perspective when the modeler is the model is the modeler is the model. It's a loop.

53:29
Cool. Dave, would you like to say hello or ask anything? Hi. Nothing particular to ask. Sorry to be late.

53:39 Speaker E:
I've been marinating myself in neurosychoanalysis for the last week and a half. That's my Costa. I've dot two an. Excuse me. Fair enough.

53:52 Daniel:
So let's go to a few of the other topics that we had written down. So I think before we get to this more the liftoff on the post dot two, let's talk a little bit about intransitivity because in our discussions we had looked at intransitivity in a preference framework where intransitivity of preferences has been transformational in microeconomics, for example. And then there's intransitivity from a game theoretic perspective like the rock paper scissors and just strategic intransitivity, which also brings us back to the population biology modeling. But you were discussing intransitivity in a specific context, which is about the predictive brain architecture and models of cognition architectures. So could you maybe unpack a little bit what does intransitivity mean in that context?

54:49 Who disagrees? What would be different if it weren't that way?

54:55 Majid:
Yeah, sure.

55:02 The thing is that if we assume that there is transitivity information could be transferred from one unit to another, we would have a serious problem in defending I was thinking of saying something more about active Inference and active Inference Lab, but I will put this on the background for the time being. But the thing is that the point that I was trying to make in the paper was that all of this talk about the distinction between transmissivity and intransitivity only works with regard to invoking a specific kind of models. Which is no wonder because the paper is about the significance of scientific models. So we can defend transitivity or intransitivity of the cognition structure depending on the kind of modeling that we are on. So if we assume that the only kind of models that are loyable in the context of free energy principle are dynamical causal models, we will end up by a straightforward rejection of modularity.

56:13 But this doesn't need to be the case because free energy principle not all about representing the actual causal mechanisms, neurophysiological mechanisms of the brain. So this is as much about

representing this neurophysiological structures as the general properties of the it is as much about representing the local significant neurophysiological mechanism as it is about explaining the relation between different units and different component counterparts that are implemented in the brain. So it is supposed to be a unifying theory of the brain and in some sense it may indicate that we do not need modularity enough because if we want to defend some sort of unity between different components, between different parts of the structure, we do not need to be able to modulate the brain. And the paper tries to argue the reverse that speaking of the connection between different parts in terms of mainly in terms of again, it comes back to the distinctions between effective functionality and function connectivity that you discussed very well. Most probably better than I would be able to in the previous session would be a matter of the kind of properties of the collective system that we aim to model by invoking free energy principle, whether there are local properties of the brain or the global unifying properties of the brain.

57:50 And if we want to model the brain in its unity, we also need to be able to speak about the connection between different parts. And from the very fact that we assume that there are different parts, it follows us. We have to assume that there is some sort of encapsulation or a weak point, a moderate form of modularity.

58:16 Daniel:
Very interesting. Thank you. Any other thoughts on that cell? Then I'm going to go to a hard question, which is what makes a model active inference? Is that in the circle or out of the circle?

58:34 Is it a binary classifier? Is it a zero to one scale?

58:42 What will happen when people disagree? Does simply any model involving action and inference qualify as active inference?

58:55 We have asked it on a few previous discussions and I think we have gotten a range of answers but it's definitely an important one to revisit from this model based science perspective.

59:15 Majid:
Well, I have been defending some sort of pan psychism. I have been Attial in free energy principle in defense of versions of pan psychism. So I'm tempted to say that any kind of selforganizing system that can minimize the discrepancy between its internal model models and the environment is capable of forming active inference, but it is not directly to I mean, it is not specifically related to this issue of model relativity unless we assume that model relativity is quite obey. It is everywhere in scientific activity. I cannot find any specific relation between that kind of pan psyche account of active imprints and a specific discussion of model relativity.

1:00:15 Dean:
Data. Can I ask a question? Yes. Dean sorry. Bleu.

1:00:20 Maybe you want to go first? You put your hand up, and I just blurted out, go ahead, Dean okay. Sorry about that. Thanks. So, at the end of the last livestream, there was a question posted in the live chat about so does active and maybe this ties in with what you're just asking.

1:00:37 Daniel does active inference what does active inference tell us about the model of the person trying to kick the ball? And I'm curious about this Laje because you wrote another paper with a co author, a paper on active inference and abduction with somebody by if I pronounce their last name

incorrectly, I apologize. PIA Taranin and I'm kind of curious because I think what active inference enacting active inference lab within model building and modularity is it gets us asking a question much like Charles Saunders Pierce would ask if you walked in late on Bob and Alice. Okay, it's 09:00, but you're not really paying attention to the clock right now. You just walk into a room, and there's on the other side of the one way mirror is subdivided two cubes, one with Bob and one with align.

1:01:35 But you've walked in and you don't have a model yet other than the fact that you're on the other side of the curtain. You don't have a smiley face or a frowny face. What you have is a moment where you have to ask if you're actively inferring and you're enacting. This is what should I be surprised if and what should I not be surprised if as the as the stuff that's carrying out in Bob's room somehow appears to not being carried out in Alice's room. So I don't know that modeling can sort of segregate itself out scale free from the idea of the specifics.

1:02:21 Like Pierce would say, if you walked in into a room and somebody office of you had a bunch of white beans in their left hand and a bag of beans in their right hand and asked you, as the person walking to the room, did these beans in this one hand come from this bag? You wouldn't have enough information to be able to give a specific and clear answer to that. But you could start a process of modeling. You could start a modularity exercise to try and gather from an abductive sense what led up to this moment. And so I'm just kind of wondering, migid how you take this paper and that example and sort of ties in with some of the other work that you've been, because I'm hoping maybe I'll talk to you after this, but maybe I would lieke.

1:03:18 De Boer able to review your active inference and abduction paper as well, if you have time. Anyway, I'm just wondering what because I think if we're looking at this from active inference and enacting, sometimes we walk in and we walk in and we have to infer based on a limited amount of information. And so I think that's what we're trying to do. We're basically saying when we walk in, do or don't be surprised if and then whatever plays out approximately on those timescales next.

1:03:51 Majid:
Yes, I do agree. Well, I'm very happy that you mentioned that paper because I wanted to speak about that, too, earlier. So the thing is that, as I say, there are two phases of the same project. So in this project, in the project that has been stated in a tale of two architectures and in another paper, a critical artist of Mark Kobe and Monism, I was emphasizing the model base, model relative nature, active inference lab and activities. But the main reason why I was getting interested in this, because of the Markov blankets, because I think that Markov blankets are also very strong and reliable modeling tools also for the general scientific modeling purposes.

1:04:43 So it is the other side of my project when I'm trying to goal scientific realism and scientific model making active inference lab and free energy principle. So this is the other side. And going back to the general arguments for scientific realism. Again, a strong version of defense of scientific realism is reliant on invoking explanatory inferences by developing something that is called inference to the best explanation. And the project that you mentioned, the paper that has been written by me and Aussie and there is another paper we were collaborating on another paper on the same subject, aims to show that how the general explanatory inferences, how the general abduction is grounded in the process active inference lab.

1:05:40 Right. So I think that there are two sides of the same coin and there are two intertwined, two interrelated projects. But as I say, I do not see do you want to also explore the implications of that for the metaphor of Bob and Olives? I mean, do you think that it has any specific ramifications for this Bob

and Olive? Smithophore yeah, that's exactly what I think it does.

1:06:13 Dean:
And again, it's a separate paper. And there's another excellent insight if you get a chance to read it. But I think when we're trying to figure out what's effective and functional, we come into a situation looking at Bob and Alice and over time, our model grows as well. Right? And I think that's part of where my question about what is scale free?

1:06:43 Yes, Bob and Alice are in their cubicles and those cubes are of the same dimensions. And then there's a scale friendly part that kind of grows over those slices of time. So yes, I actually do think that it would be interesting to sort of say when did we walk in on this Bob and Alice observation? Very well. So I would say that for the moderate victims of encapsulation that is at issue in this specific paper a tale of two City, the necessary cognition is that the information in each unit is not available to the person in the other units or in the other black.

1:07:25 Majid:
So to the extent that the information about, for examples, Bob brushing his teeth is not available to align, there is some sort of weak encapsulation and I think that it is enough for establishing some sort of moderate correlation. But the other part, the more fundamental question about the scale relativity and to what extent it is some sort of scientific fact that we can choose the scale that we need on the basis of our explanatory interest. So at this specific setting, my explanatory interest, my scientific interest was to set the limits of the scale at the level of the rooms of Bob and Alice because I wanted to explain encapsulation. So in other situations so assume that you are an information theories and you want to develop a general theory of communication between these two units. So it is natural for you to take the point of view of the third person of another observer and then there might be another person who wants to speak about the relation between this third person and the target system, etc.

1:08:38 So it might go observer all the way up and observer all the way down and it would be a matter of what you are trying to do with changing the scale, what goal do you aim to achieve? So again, at some papers I was trying to stay limited to the level of individuals. So for example, when I wanted to model the activity of a scientist, specifics and individual scientists, I was focusing on the processes of inclination of predictions at the level of individuals. But at points I wanted to model the behavior or speak about the behavior of all scientific community, assuming that scientific practice is a social act. And for that reason I was trying to expand the limits of the scale and apply that to the whole community of scientists or a specific group of scientists rather than individual scientists.

1:09:41 What was important for me and what I think is important is to have good and satisfactory justifications for changing the level, to be able to explain clearly what was the purpose of changing the level, taking it to an upper level or a lower level. And I think that to the extent that we are speaking about encapsulation and modulation, it is justifiable to limit the module to the specific cell in which Bob and Olives are dwelling.

1:10:14 Daniel:
So just wrote a few things down and maybe this captures it, but the free energy principle, especially as you're applying it in this embodied informational and cognitive structural realism perspective. The FEP as a theory of things is providing the conceptual continuity for modeling different complex systems, including scientists in the world and other processes as they engage in their niche. And then the active inference framework we can say is operationalizing this imperative for persistence of different systems and then connecting a priori process ontology to a whole host of other patterns, motifs that we must

explain in the world. Like abduction in the social and communication case and narrative information inference on one end of us, but then on the other end, we also want to have active, really dial in and get at exact inference in certain cases. Where it's like we made the fMRI measurements and we kind of want to leave philosophy in the lab and just plug and chug this pipeline.

1:11:40 And we don't want that to be a pipeline of nowhere or we don't want the output of the pipeline to be interpretation in a fallacious philosophical milieu. But at the same time, if we try to take that philosophical baggage through every step of the processor and the Ram and the GPU, we get into these little nano debates, which you highlighted, which is like people arguing whether cyclic or directed acyclic, graphical models have philosophical impact when they're both just models that scientists chose for different reasons.

1:12:24 Majid:
I have to say that you have the knock of explaining my ideas far more clearly than I can.

1:12:32 Dean:
Force everybody. Vegeta is a brilliant young man. Here's my next question for you because there's multiple FEP frontiers. Here you have the book, then there's the Markovian Monism that we had earlier discussed, the abduction one, which we haven't gotten a chance to discuss this paper, obviously. So how do you keep the information organized or assess how new papers coming in play into how you want to develop these different threads of research?

1:13:11 Daniel:
Or determine where you can be making an impact by targeting this paper or assessing this phenomena or stepping into this 5000 year old philosophical debate?

1:13:29 Majid:
Well, it is very hard to explain where these ideas are coming from.

1:13:41 If I could state the process in this fashion, most probably I would be able to hire someone to write a program that does this instead of doing that myself. So I think that it is mainly a matter of intuition, although it is and it is very ironical because philosophically I'm not someone who escorts too much credit by the intuition. But I think that I have a general program and as I said, I'm trying to defend some sort of moderate version of cognitive realism that tries to account for scientific representation, to grow scientific representation in the relationship between a community of selforganizing agents and their environment. So I think that's why I'm starting from the simpler bits. So, for example, starting by just stating the point that scientific representation could be grounded in free energy principle and then I'm just flashing out the other complex issues.

1:14:52 So, for example, as they say, one thing leads to another. As soon as you try to account for scientific representation in terms of free energy principle, people point out and there have been excellent papers by excellent criticism, for example by Max Jones who were pointing to this criticism that science is not an individual activity, it is a social activity. And then I am going back to play showed the social aspects of my view. So I think that it is again some sort of dynamical social process that leads to the development of these ideas. And then when I'm trying to deal with this social aspect, I stumble on reading Thomas Kune and I see that I have to also take care of theory relatedness, for example, I engage with that issue.

1:15:44 But I think as I started to work on this, applying this model relativity, the model based nature

of scientific activity to philosophy of mind since 2016, and then one thing led to another, and I'm very I have no idea what impact would this project lead to? What group of people? Because most probably the project is a bit too scientific for philosophers and a bit too philosophical for scientists. But it is the only way that I know for developing my philosophical ideas.

1:16:32 Awesome. Thank you. Bleu if you wanted to raise your hand, otherwise go for it. If not, then get Bleu, then leave. To I think my comment was kind of old at this point, but really like I was just curious about linking this or under what circumstances or how can we apply this active inference lab framework to partially encapsulated systems.

1:17:06 Bleu:
And so, I mean, I think that this is it gets into like I guess that's the big question, right? So always just I would love to hear your thoughts on how information is passed from module to module or what is this idea of mutual information in the collective pansychism sense? Like how do you think or to what degree is it shared? And can you perhaps maybe shed some light on mathematically ways that you think it would make sense to talk about partial encapsulation?

1:17:43 Majid:
Well, sourcing flow from the last part. I think that mathematical representation is rather the easier part. So we can easily model this partial encapsulation by invoking some sort of partial isomorphism. So it is enough to have two sets of models and try to show that to what extent or to what correlation, what subparts of the sets are related to what subsets of the other system. To the extent that there are significant chunks that are not related together through some sort of isomorphic relation, we can retain some sort of partial isomorphism the other way.

1:18:29 I think that the other more intuitive way of doing that is by invoking Markov blankets. As a matter of fact, I think that partial encapsulation is a direct result ramification of. Invoking Marcovia and Blankets because they are sitting some sort of conditional independence between different Chinese, right?

1:18:55 Well, from the very fact that there is some sort of partial encapsulation, it doesn't follow that there is no amount of transfer of information between the Chinese at all. The only thing that is necessary for retaining this partial encapsulation is that at a given moment there is no actual. So the only thing I think that the necessary condition and it is very minimal for retaining some sort of Attial encapsulation, is that at any given time, information at one unit is not accessible to the observer in the other unit. And I think that this
condition could be satisfied quite easily. This is why I think that some sort of partial encapsulation endures despite the validity of Kirchhoff and his biological argument.

1:19:47 Daniel:
Thanks, Bleu. And then go ahead.

1:19:55 Bleu:
My question was probably backwards. So what about how is information shared? How do you demonstrate information sharing as opposed to information encapsulation? If there's a Markov blanket, we establish conditional independence. But where can we establish conditional dependence?

1:20:14 Or how can we establish conditional dependence? Orex Verbal Hae Park. That's really I'm curious about sorry. All right. Very cell.

1:20:23 Majid:
Look, the internal and external states or the sensory and active states are related together. But the thing is that the observer or if you are encapsulated inside the markup blanket, you can infer the properties of outside only indirectly. So what I was trying to do to some extent is to instead of assuming that the collective system is composed of Marko blankets, I tried to put myself inside the marker blanket and see how could I get access to information that is outside the markup blanket or inside another markup blanket. And to the extent that there is no direct relation or the information is not directly accessible at a given time, I think that some sort of encapsulation induced.

1:21:15 Daniel:
It'S like a cup half full, cup half empty, channel half open, channel half closed. It's the two extremes. Complete integration, which maybe doesn't even make any sense, like a solid state drive. What would it even mean if all the information were connected to all the other information at the same time? It's just not compatible with the architectures of physical systems.

1:21:43 So, interesting thought experiments, though, for total integration. And then any realized system is either going to be fully conditionally independent, entirely Markov blanketed or there'll be some partial relation and then part of the realism and instrumentalism, okay, that partial correlation can be an edge, like an effective or a functional connectivity edge, which doesn't imply a causal role. It's a scientific projection, situationally defined edge that's being inferred in a specific statistics framework. And then there are hidden states of the world of observers who are supposing causes like hypotheses about how things happen in the world. And then they engage in all kinds of studies like loss of function, gain of function, blinded research those are protocols or affordance that scientists engage in to reduce their uncertainty about this hypothesis space.

1:22:54 So it's a very interesting area, Dave, and then Dean right. It's perfectly into what I was going to ask about. Where you draw the boundaries, where you draw the blanket states really important. I like to say nasty things about donald hoffman, or more specifically, the way he allows himself to be portrayed is thinking that there's absolute freedom and putting blankets wherever you want, that the boundary are totally arbitrary. And so we are all one, blah, blah, blah.

1:23:35 Speaker E:
Really, though, blanketing is a matter of what's actually happening. Are you Majid familiar? There we go. Are you familiar with Mara Beller's work on the level of actual scientific interactions?

1:23:54 Daniel:
Can you describe that work a little bit? Monroe belief? Yeah. For a number of years, she was perhaps the learning historian of the early days of quantum mechanics. And as she got more and more in depth into what actually was happening, there are certain papers by Bohr that are widely regarded as being totally incomprehensible.

1:24:18 Speaker E:
You go from one thing that he's saying in the paper to a few sentences later, and there doesn't seem to be any connection at all. And people were thinking, cell, what was he lost? Was he too tired when he gave this talk? Well, she went down and trying to take sentence by sentence and phrase by phrase, asking the same question that a good drama coach asks for each statement that you have to deliver, what question is that speech an answer to? And she found if you went through the people that force was an intimate dialogue with, whether he was on their side or being driven crazy by them, like Einstein, if

you kept that in mind and asked, who was he talking to?

1:25:06 Who was born talking to? At each moment, everything became very straightforward. He was having a series of dialogues with a dozen people and just stringing one fragment of the dialogue after another. And I haven't read it yet, but that totally ties in with the concept of conversation theory, which was something put together in the 1960s and 70s by my teacher of cybernetics learning theory, Gordon Pask, who defines the minimum unit of consciousness as the conversation and also represents each conversation, or at least each enduring conversation, as a psychological individual. So you have very much Nested Markov blankets.

1:26:01 You have very much the, like, Nitsean hierarchy and the indefinitely large or infinitely large and deep hierarchy of Ines composed of minds. Composed of minds.

1:26:18 And the way Bellman presents that, that's what science is about, having lots of dialogues, figuring out how they fit together the dialogues, beginning new dialogues. And in past sense, those conversations themselves, in the best case, become the enduring individuals, maybe the immortal individuals that make up a successful living science.

1:26:47 Majid:
Well, thank you very much for the input. I agree that the issue of choosing the scale is not arbitrary. So I think that earlier in the paper, I refer to the works of Rhodeolf Carnap and Thomas Koon to point out that I think that there should be some general considerations that rule over the choice of a specific scale. This is partly determined by the property of the target system itself and partly by the interest of the modeler, depending on what the model is trying to work out about the target system. So I completely agree with that.

1:27:27 And about the collaborative and distinctions. I don't know whether it is I'm reading too much onto what you said, right? Into what you said, right. But I'm completely on board with some sort of collective attributes take on scientific activity. And this is something that I have been defending in recent papers in the previous year.

1:27:53 So I completely agree with that.

1:28:01 The point about individuals and how to define an individual or the borders of consciousness, the limits of consciousness, is still very much at the center of my intellectual enterprises. So this is something that I'm trying to explore more and this is something that I'm thinking about these days, whether the unit of scientific activity is a region in the population of neurons in the brain of scientists or an individual scientist or a group of scientists. So these are all very interesting topics. Thank you very much. Thanks for the response.

1:28:49 Daniel:
So Dean and then Bleu. So Magic, I think what you've done is you've hit on a really important point and that is that whenever we do isomorphism, we can sort of take an isobet stance. I've read a book a long time ago by the editor author was James Brockwell. It was called the visual world and memory. And what he said was that the way that we capture can be one of two types, the ISOBUS stance that sort of isomorphism that we're outside and we're creating a representation with frames around them.

1:29:34 Dean:
Or we can be spatially enveloped, which kind of ties in really conveniently with the idea of being either

in the cubby hole that Bob is in or Alice is in or anybody that's within spatially enveloped within that sort of entailed world where we're sort of now the subject of whatever the walls are limiting us from being able to see. And so I don't think we walk away from the idea that we can make models. We just have to be able to ask on a moment, especially to Blue's point, how do we make something available as opposed to keeping it sort of cleaved off or sectioned off? We have to kind of take the perspective or the view of the person who's enveloped, who doesn't necessarily have that isovistmodel ability to nest thing and look at the world from their eyes, which is okay. It's not what you're seeing necessarily in terms of what's on the page.

1:30:37 It's how you're entering the room with maybe not as much background and not as much as ability to step outside of all of this information and start juggling. And so I think that is one of the really key points to try to remember here when we model that just because I have a model that I can take that eyes of a stance doesn't mean I am. Able to also remember what it was like to be the one sort of captured or enveloped by less information, but still trying to catch up. I think if we can hold both up at once, it's back to that minimum two things at once. Don't be surprised if do be surprised if or active and inference.

1:31:21 Like, I think what we're really basically saying here is bumping it up by including two things. That sort of depth perception piece. Yes, it does make it more complicated or complex, but that doesn't mean it's overwhelming. It gets overwhelming if you try to do, I guess, maybe seven or ten dimensions at once. But we can bump up to two.

1:31:45 We can take the eyes of a stance, we can do the model, and we can also remember what it was like to be spatially enveloped. You're going to get overwhelmed and surprised by the real world when the train comes at you if you don't have depth perception. So it's a very interesting take. Dean yes, two and two is truer than one, but also there's other benefits, too. Bleu so, just to kind of clarify what I was talking about earlier and then add on to what Dave was saying, I want to know how to draw a partial Markov blanket.

1:32:26 Bleu:
To me, a Markov blanket represents a distinct boundary between self and other, internal and external. And so how do you make this kind of partial Markov blanket? And I like what Dave was saying or about what his teacher put forward about the conversation being a unit of consciousness. And I am very much Ascriber to panpsychism. I don't think that it necessarily needs to be a conversation between two humans.

1:32:56 But really, maybe fundamentally, each relationship between two objects, perhaps each relationship has then its own Markov blanket, like my heart and my liver have a relationship with each other that that itself is encapsulated with a markup blanket. And this can be attributes to any two cells or two organisms or so on and so forth.

1:33:27 Majid:
Very well. So, by the way of an example, I completely agree, especially about the part that this well, I do not want to use the term conversation because I do not know the theoretical implications very well. But I think that when I started this project, for example, on modeling scientific activity as some sort active inference lab, I was thinking of individual scientists as the units of scientific activity. So an individual scientist has been enveloped by Markov blanket, and she was trying to get an access to the causal structure of the world by forming inference from beyond the blanket. But as I worked more on this aspect I understood that the situation is becoming complex very quickly.

1:34:32 So then I thought that we could put all of the scientific group or scientific community inside the mark of blanket and then try to exploration their relation with the environment as the parts of a general Markov blanket by just expanding the scale that includes them. And then at the stage I also thought that we could also model in the same way that we could envelope the relation between two scientists inside the mark of blanket, we could just expand that and also include the artifacts, the scientific experimental tools inside the community of the scientists. So scientific activity is basically about the relation between scientists, scientists, human human activity and human artifact relationship. And scientific activity is distributed to all of this group which includes both human beings and artifacts. And then depending on your take on free energy principle, whether you are defending internal representation stance or an activist stance, you can speak about the relation of this group to their environment in terms of classical representation or coupling or a Hebrew view which includes interface representation and coupling.

1:35:59 Daniel:
Thank you. Very interesting. Makes me think about science and technology and how the word science relates to, like, a lot of inference and sigh and scry and all that, and then technology technique and that has a little bit more of the implication of tool deployment and finesse and measurement and the blurry line between science and technology and the who and the what and the how. So it's very cool in our last little bit here. First, if anybody watching live has questions, we totally can address them.

1:36:40 But this was the question that we left off on at the end of the one video, which was how do you utilize functional and effective connectivity in active inference analysis to better inform an answer to a question such as in football, why I scored the goal? So how does that enrich in analysis? Because we've talked a lot about how the chosen models deployed by scientists are goal driven and so what exactly is active inference helping us do? Or how is it enriching our account of a situation like scoring a goal in a sports ball game.

1:37:29 Majid:
Cell? As a philosopher I feel that I have to stay silent about this question to avoid revealing my deep affordance of the technical aspects of how this works.

1:37:42 I have some general idea and I can try, but I think that it would be better to stay silent and not reveal my ignorance. How about learning off with something ignorant and then we'll see if any other researchers have thoughts? Well, I do not know about this specific example, but for me the distinction between functional connectivity and effective connectivity was about the causal physical aspects of the target system and the general goal and structural features of the system. So I was not thinking of this in terms of the point that I was trying to make. Whether to try to focus on modeling the causal physical aspects or focus on the structure or goal aspects would be a matter of the interest of the scientist or the modeler.

1:38:35 Whether at the moment or whether in order to do the task at hand, she prefers to stay focused on the general aspect, speaking about the relation between different parts in unifying structure terms or going into the details and trying to model local specific features. I'm not quite sure how I can apply that to the example of scoring a goal.

1:39:08 Daniel:
Dean or anyone else. I just think it's been scoring the goal. Again, pre kicking the ball, you could be asking yourself two questions why am I surprised about the result? Or should I be surprised about the

result? Because I think that's what active inference affords.

1:39:31 Dean:
It gives you that possibility of two outcomes I scored a goal or I kicked it up into the stands. But before you actually kicked the ball, perhaps if you're not really, really skilled at kicking a ball, you can ask yourself whether or not there's enough in this particular case mechanical familiarity and background to actually finish off what you intended to do. That's what I think active inference allows for. But again, my ignorance shines through too.

1:40:09 Daniel:
Okay, I'll give a thought. So I think there's active inference and then there's functional and effective connectivity because functional and effective connectivity have gone back further. So first, applying the techniques of functional effective connectivity help us separate out hypotheses about physical causal mechanisms from a whole variety of different kinds of edges that might be applied. Like there's time correlation, there's mutual information, there's change with respect to like condition on this one going up in that split second, this one goes up as well. So all kinds of different edges that can be drawn essentially in a graphical framework.

1:40:55 So not just like visual, but on nodes and edges. Active inference gives us a lot of other things. So this of course would not be a complete or authoritative answer, but it does provide us with a framework and a nexus and a community that can scaffold and nurture accounts of the target phenomena. So kicking a goal. We want to have the biomechanics researcher and the force on the knee and physical rehab and then also there's an easy way to go into like the social inter connectivity of the game rules and regimes of attention and thinking through other teammates and cyber physical systems of the soccer stadium and then like reviewer to just addressing the inner or outer critic and knowing that we don't need to have a theory of everything to talk about the ball being kicked.

1:41:58 So I'd say that ActInf specifically provides value for the researcher, the goal scoring researcher, because it will help them reduce their uncertainty about what contribution to make to the research literature by just saying like giving really good connection points. If they're doing the biomechanics paper, it can have awesome connection points to the cultural and the social and all of that. And if they're doing the social paper, it could have nice articulation with the biomechanics and that would even be before we get into the some of the details of the active modeling per se.

1:42:44 So if anyone in the live chat would like any final questions, otherwise we will sort of cruise out, you know, in the dot zero. We do the background and it's the time that we all need to take to work through these very provocative and interesting and farreaching papers. One is a lot of times like a mess because we're exploring a lot of different avenues and we never finished them all in the dot two. But this is sort of where we take off into our next set of discussions. It happens to be that in the coming weeks we're going to be talking about the nature of self representation.

1:43:23 So that might have some themes, but Majid, I'm just curious, like, what are you excited about for 2022? What directions or policies are, like, exciting to you now that you've very recently completed this work? I'm excited about a new book that is under review. So structural realism, as I said, was the official wisdom of philosophy of science for quite a while. And I tried to develop a cognitive version of a structural realism before no, in a new book that is going to be in a new book that is going to be published.

1:44:08 Majid:

I mean, it is a sequel to the book that you are seeing. The new book that is under review. Right. I'm going to play show the social aspects of scientific activity. So a structuralist despite all of their virtues, they were not too much attending speaking about the social aspects of science.

1:44:25 And I think that that aspect has been to some extent neglected in the contemporary philosophy of science. So it had its high DAG in works of Thomas Jun, Tani, firebend, and then it has been pushed into the background and now I'm building upon free energy principle. So the theories of social communication that are grounded in free energy principle to bring back this discourse on social aspects of scientific activity. So the book that is under review is the title is aptly called bringing Social Awareness to a Structural Realism. So I'm very excited about that.

1:45:08 I still do not know whether it will pass the review and whether it will go to the press or not, but I'm very much excited about that.

1:45:20 Daniel:
Nice. It reminds me of Bruno Latour Reassembling, the Social. Of course, different aim, but that almost feels invoked in the title Cell. It is a different aim, but as I say, it is mainly about works of Thomas Kuhn and Paraben, but it also has references to the works of social constructivist, Latour and others. And specifically sorry, I have to change the place to put my laptop into the charge again.

1:45:51 Majid:
But the thing is that Latour was one of the main people who was complaining about this kind of dismissiveness of social aspects of scientific activity. And I think that people who were working in distributed cognition, they're actually explicitly mentioning works of Lottor and some other social cognition niche find a foothold for dating cognition or knowledge as some sort of distributed social activity. So what I try to do is to develop some sort of elective distributed account of scientific cognitive studies has been something that people such as Ronald garyh have been doing before and nonsense and some other people are doing these days. But what I was trying to do is to try to reinforce and reconstruct these very interesting insights by drawing more recent developments in free energy principle. So some sort of free energy principle account of social communication.

1:47:04 I'm building up on that to reconstruct classical accounts of distributed scientific cognition, which as well has its roots in works of Lattoo and some other social faculty social constructors. So you are very short to spot the relation again. Cool. Nice connection there. Looking forward to that.

1:47:27 Daniel:
Like after network theory, Kant distributed systems kind of makes sense.

1:47:36 Well, I think if anyone else wants to give a final thought or comment, anyone other than the Anthony Chen, we'll provide the last word to the author. So Bleu. And then either Dave or Dean. This is a lot of like fun thought experiments and just thanks for your time and as any good paper opens more questions than provides answers I think. So I'm curious to see what your next work is and how it all unfolds in the future.

1:48:11 Majid:
Oh, thank you very much for your contribution as well, Dean. And then, Dave, if you would like. Majid, as I mentioned earlier, I hope that in a couple of months'time and there's a slot where you have some availability, I would like to also look at this work that you've done around abduction and the idea of active inference as well. Because I think in terms of trying to be able to cast a wider net and get a

better sense of how we model and look at things through. Time frames both before, during and after.

1:48:55 Dean:
I think that would be something that I'd like to take up, because going through this paper certainly brought a lot of things to the forum was really, really helpful. So thank you very much. Thank you for showing up today. We really appreciate it. Mr.

1:49:09 Majid:
Sal, thank you very much for your interest. So I learned quite a lot too, both from participating today and from watching the video with the previous video of the discussion. Great. Well, as always, super fun to read and to interact with you to take it from a epistemic stigma g interaction with your asynchronous artifact into something that is spatially remote but still interactive hashtag effective connectivity. So just keep in contact with us at any time you would like to discuss more or do anything else with the lab, just be in touch and anyone else as well.

1:49:52 Daniel:
All right, great times. Thank you, everybody. Thank you very much. I'm sorry for being a bit busy after teaching at this end of the semester hassle. So thank you very much.

1:50:04 Majid:
Take care. Excellent. See you all later.