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The first ten years of trying to catch a milkshake acting like a computer: A response to readers, students, and colleagues

Damian G. Kelty-Stephen

Grinnell College

The milkshake acting like a computer is an idea that appeared on my stupid professional website ten years ago when I was first struggling to begin a straight-faced professional, academic “web presence.” This text here has no new empirical evidence and is not an attempt to develop theory in any way. It is an attempt to thank the digital community of scholars that has kept me afloat for these past 10 years by answering some of the questions and concerns that the sea of digits has thrown my way. I aim here for a format that is hopefully easier to read and more open to discussion than much of the peer-reviewed literature. I would ask that people read this document in the spirit of open review. And if you have any comments, questions, or thoughts, I’m asking right now for you to please share them to help me make the future of milkshakes acting like computers ever better than the milkshakes past.

It has been roughly 10 years since my name went into scholarly print. I am not celebrating, but it has been a nice time to sit back and reflect on the wild ride. No one in particular wanted me to type this document up, but I thought it might be nice to address some of the bigger, recurring concerns that readers and reviewers have posed to me over the years. So, consider yourself warned up front: there is no empirical finding or theoretical development in this piece. All I am providing here are personal recollections and observations from ten years of trying to catch milkshakes acting like computers.

The beginning (and often end) of my digital identity as a scientist

It was about ten years ago that, eyes slightly rolling, I began to set up what my slightly-elders and betters encouraged as my “web presence.” As a relatively young scholar but a relatively old millennial, I was unaware of so much. Here’s a short but hefty list of blind spots:

1. I was self consumedly occupied with dreams of academic accomplishment and aspirations towards a late Victorian notion of scientific elegance.
2. I was not aware of absurdly many constraints both supporting and slowing my progress beyond my immediate awareness or even beyond my control.
3. I did not know that rational argument aligned with empirical evidence was insufficient to change all scientific minds.
4. I did not know that scholarly communications had complex roots in legal and economic landscapes carved by nonscientific glaciers before all of us were born.
5. I did not know that Google was pursuing both intellectual and commercial projects with unprecedented scope and unprecedented resources entailing long-range collisions with the socioeconomic facts of communication, education, and academic funding.

I know so little still to this day, but what’s crucial is that, when I started hacking away at a public image on the web of data packets, I was completely ignorant about those concerns. Maybe knowing what little I know just risks making me a more pompous ass now than I was then. So reader, beware.

Having dipped my toe into the raging waters of scholarly communication, I was supposed to start my "web presence?" What, I proudly scoffed to myself, was I supposed to dumb my scientific identity down into a Myspace profile? Some how, in my flippant ignorance, I responded to this task with a drip of insight that I cannot shake off and that seems only to echo across what would have seemed to my younger self as the more important parts of my professional trajectory. The web presence began with a question: "how does a milkshake act like a computer?" I wanted the quickest, glibbest, funniest bit of snark that could get my point across. And I think I got it right—or at least can look back on it and not hate it as another trace of my oblivious posturing.

For better or worse, this goofy question may be most of what most people know about me. My professional identity is spread over very many digits in the internet cloud, and most of those digits that people encounter begin and end with the milkshake acting like a computer. And I'm quite aware how few of my published words even make it even so far as the retinas on the internet. Heck, my habit is to discourage those people closest to me from reading my articles. After all, the in person conversation can be so much more edifying and enjoyable. Why read what you can ask someone for point blank? But for any stranger who doesn't know me well enough to care what I think, I am most sure that computer-posing milkshake has gotten across. Most readers forget it, but I've had enough unexpected feedback suggesting that the milkshake sticks with people.

I want to address a few questions or curiosities that keep coming back to me whether in classes or in conversations or in anonymous peer reviews. And these questions may begin and end with that dratted milkshake, which is as much my critique of computational perspectives of psychology as it is the beating heart of my digital identity as a scholar in an age of clicks on the Internet.

To start this document off, I review briefly what I meant, but if you're already reading this far, you may already be part of the choir not needing the persuasion, please drop in to later sections of the document using these linked questions that you might want answers to:

The milkshake-acting-as-a-computer metaphor is not a computer metaphor

[What do you really mean about the milkshake acting like a computer?](#)

[But you don't study computers?](#)

[Okay, but no one seriously takes the computer metaphor literally. Aren't you choosing fight-starting rhetoric over actually constructive discussion?](#)

[Isn't an anti-computational perspective tragically an appeal to magic, mystery, and some non-material spirituality rather than a genuine scientific position?](#)

[Well, have you ever considered that maybe the milkshake is a quantum computer?](#)

Progress and current limitations/questions/challenges

[Okay, so how is the non-computer milkshake faring 10 years later?](#)

[Does all of this multifractal modeling mean you can describe what you think in a way that does not require smirky references to milkshakes bashing computers?](#)

Misconceptions worth contradicting

[Don't you think brains are useless?](#)

[Aren't multifractal analysis getting us away from seeing the real data?](#)

[If everything is fractal, doesn't that mean that there is no control condition and so that fractal results cannot tell us anything?](#)

[Are multifractal results indicative of the whole system?](#)

[I have heard that we don't have the proper mathematical toolset to make dynamical-systems/complexity/multifractal/cascade-theoretical testable, that our measurements are not the right sort for these analyses at all. Why shouldn't cascades and milkshakes remain purely metaphors or narratives? I like the narrative but I don't like or trust the math, and the narrative seems better than the other guys'.](#)

[You must have majored in math to do what you're doing, right? Psychologists don't do math.](#)

Open science seems exciting and sometimes scary

[I am a digital-age scholar through and through, yet another milkshake acting like a computer ready for you to click on and read through as you like.](#)

“What do you really mean about the milkshake acting like a computer?”

Well, at the risk of ruining the joke by explaining it, I want to be clear for anyone who thinks it is not a good joke anyway. When I said “milkshake,” I meant “brain” because

1. many psychologists think minds are brains
2. brains are made of fat, sugar, and water, like milkshakes.

Behind my joke is a more serious set of points that are not mine but that I agree very much with:

1. Brains/minds aren't computers
2. Computation is very little of what we do.
3. Computation is certainly not how we do everything else that is not computation.
4. We are unremarkable matter (fat, sugar, and water) that has woven itself into remarkable patterns.
5. That remarkable weaving is the very often accidental and contingent product of factors unfolding inside and beyond us
6. The accidental and contingent nature of the weavings has room for and has launched an intention or two, or twenty.

Any time that I have risked forgetting that the brain is more milkshake than computer, I have risked the following leap: “Well, remarkable patterns must come from remarkable origins.” Or “Intentional actions must always come from outcome-directed dynamics.” Certainly, both could be correct, but no matter how many times I try the leap for myself, I'm not convinced. Evolution never knows what it's growing into because natural selection is really just contingent death, and development is not necessarily a straightforward chain of events from resembling causes.

“But you don’t study computers?”

Right, I don’t. But an important part of that digital identity as a scientist in a world where Google sells advertising is that I only have five seconds to communicate with most readers. If I used those five seconds to say “I model goal-directed behavior using multifractal geometry designed to address sometimes-turbulent fluid flow,” then not even I would want to read my stuff.

And it’s actually the very fact that brains/minds are not computers that would make such explicit phrasing in my own personal advertising a weak strategy for encouraging discourse.

“Okay, but no one seriously takes the computer metaphor literally. Aren’t you choosing fight-starting rhetoric over actually constructive discussion?”

I don’t want to think that anyone seriously thinks that brains are actually equivalent to computers. Unfortunately, the technologist chatter about “noospheres” and “singularities” suggests that some well-educated people may think such silly things (see Jarod Lanier’s [You Are Not a Gadget](#) if only to see that I’m not imagining it or alone in finding it unfortunate). And before I come clean in a new crowd of peers, I get to hear all manner of excited questions about, say, the “refresh rate” of the brain.

At best, computers are just a metaphor, and no metaphors are perfect equivalences. Metaphors are fine and good, and we need them in science. But I think that there are better metaphors for the mind or brain than computers. Cascades are my current favorite, but that doesn’t really matter because lots of people are hung up on computer metaphors for the brain or the mind.

Whether you worry more about equivalence or usefulness of metaphor, computers strike me as deeply unreliable ways to depict the mind. If you wait long enough, I could come up with as many reasons for that as you like, but right now I can think of three things that matter for the goal-directed users of computers but that do not matter for computers themselves.

Housing or embodiment

Paint your black or off-white desktop or laptop white, black, purple, or blue, and provided you have not dripped paint between the cracks, your computer will still turn on and function as before. Put your computer on wheels. Put your computer outside in the sunlight. Build the microchips from the laptop or desktop into a handheld device. Provided you still make the tiny microchip receive inputs and produce outputs in the same mechanical way every time, the housing or embodiment of the computer doesn’t change what the computer will do. None of these changes matter for the way that the microchip does its work.

Of course, the goal-directed user will care. Goal-directed users have preferences as to how they experience the world around them, and computers are just one of many artifacts that users will adapt to their preferences. Differences in pigment, differences in location, differences in ways to handle the computer—all of these differences might or might not radically change how a user probes a computer for goal-directed purposes. At a certain point, the radical changes in use could fatigue or overwhelm or break the internal workings of the microchip and other components of the computer. But that’s just to say that computers are some of the very latest in ways we humans have to project our imagined rules

through extremely small, extremely fine filters. And we can eventually strain our own devices as much as we might break our household amenities with overuse.

Note that superficial pigment, mobility, access to sunlight, and sensitivity to interactions are all things that have had a deep impact on human experience. There will hopefully never be the Twitter hashtag #BlackComputersMatter for the very reason that color has never mattered for making a computer tick. On the contrary, color has mattered very much (and very tragically) in human experience for reasons not so quickly waved off as my skepticism about computational views of the mind.

Timing

Related to this insensitivity to location and housing is a computational insensitivity to timing. No doubt, we have built global positioning satellites with computers to run on atomic clocks, but we have built computers specifically to receive and to act on inputs in discrete forms that do not force users to offer up another input.

Said more plainly, as you read this computed document, you see a continuous document. All interruptions of fluency are entirely the author's fault, and the computer file otherwise gives no clue to you the reader of

1. How many computers I have edited this document on
2. When I stopped typing in mid-document to field any number of unexpected interruptions to my focus on writing.

Also, as you read this document, you should know that you can stop reading this document at any time, and you can read it backwards or in some novel order I did not intend. You can actually make completely other use of it than I intend. Why, one might wonder, are you even still reading this document?

In short, you and I as writer and reader have immense amounts of freedom to come and go as we please. That freedom is not an accident because computers were intentionally engineered to sit and wait for the next command, the next button press, and to lend their powers of storage and retrieval in the support of our unending penchant for composing at our leisure.

Sure, we could build clear markers of temporal structure into the computed file. I might color code my words based on age, with younger keystrokes appearing in shorter-wavelength colors. I might append reader comments. I might attempt to depict the progressive branching of iterating through reader comments and my responses/revisions in newer versions of this document. But that's not what we built computers to do. [Of course, we might want to make our written documents more inviting to readers and more inspiring of dialogue, but that is crucially the subject of much human, interactive debate and effort. It is not something a computer is solving for us.](#)

Need for an expert interpreter

This third point is beaten to death in the scientific literature. So, I'd like not to have to spend as much time on it in this draft. Ultimately, computers are very elegant machines that we use to align numbers and operators against structures we encounter outside the computer. Computers only trade numbers for numbers, and it is up to the goal-directed user to interpret those numbers and make them meaningful. Interpretation is everything that computers don't do. Yes, you can make a machine learning algorithm that can take an incomplete or new stimulus and guess at its identity after having been

trained on a library of identified stimuli, but those algorithms are dogs playing fancy tricks. [At the other end of the leash are the programmers who choose the training regimen and built the library—often incompletely or poorly to often extremely regrettable results.](#)

[Actually, I think all of this has already been said best by Howard Pattee.](#) And I can't recommend Pattee's work enough any time I hear computational theories persist in psychological discourse.

In fact, the only thing I don't agree with Pattee on brings me back to the milkshake that is not a computer. Pattee seems to think that interpretation involves a sum of interpreted dynamics with an interpreting organism capable of leveraging linguistic information. Given how much else Pattee has accomplished to clarify the ideas of complexity and computation and information and biological architecture, I can't fault the genius for having cut a corner at the end of the story. But pretty much nothing I have seen yet is a simple sum, except for when we add numbers together with our computers. The programming and using that we go through to actually get the additions to happen on the screen—all of those experiences are the nonlinearities supporting the computation that happens sometime, i.e., the milkshake whipped up to produce a computation once that milkshake shoves its syrupy swirls through the filter of a matrix of digits to excite a matrix of electrons.

Without an expert interpreter, goal-directed users are only too imaginative and too ready to offer up many more than the few uses intended by the programmers and engineers. If you think that computational devices entail their own proper interpretive use, then you should see my two-year old daughter run around our house with a tape measure. She pulls the adjustable numerical constraint (i.e., the tape) up against the household artifacts in her reach and, no matter the distance she has pulled the tape, she proudly announces "40 inches." According to my daughter and her tape measure, everything in our house is 40 inches. Nothing about the computer in her hand forces my daughter to apply anything but the rule she wants. And when she gets bored, she leaves the tape measure on the floor, inertly rolled up and waiting for the next time someone cares to interpret its internal coils.

Computers just wait and entail nothing of the user. I don't think that's what minds are like.

[“Isn't an anti-computational perspective tragically an appeal to magic, mystery, and some non-material spirituality rather than a genuine scientific position?”](#)

No. No, no, and not really. And no.

Computers and, more generally, computation reflects one set of cause-and-effect relationships. There is a lot that can vary about computation (digital, continuous, etc., etc.), but what they share is a premise that

1. Participating factors have stable, local meaning
2. Participating factors denote this stable, local meaning with equally stable, local features
3. All computational processes impose relationships that hold invariantly and generically—but only throughout the universe of items embodying the previously agreed-upon stable, local features and stable, local meanings.

You can come up with a lot of fancy Turing-inspired fantasies of “self-editing, self-propelling” machines, but all of that supposed autonomy on the part of the computing machine depends on

1. A consensus among non-computer users (i.e., organisms, e.g., humans) about the set of valid meanings and features.
2. A consensus among the same users about the scale at which local, stable features/meanings are definable and made manifest in the computers.

As soon as you admit that any process (e.g., a mind) as the liberty to participate in or respond to any wider or finer range of scales than previously agreed consensus allows, then you have admitted some non-computer status. For instance, spilling my coffee on my laptop does not count as my having made a new computer function. I have changed the features (melting some of them, soaking others), and I have changed the functioning of the computer. But spilling coffee on my laptop thus makes the meanings inaccessible to the degree that those features will never again have the right shape at the right scale. So, crucially, although I can quickly innovate a new way for my computer to function, it is useless because no one wanted that new function, and the computer is what we call “broken.”

That’s all to say that computers are inert, passive, non-entailing things, but they stand for a history of social consensus that created a technology for computing. The social consensus could only have done so if it had the benefit/power of

1. choosing finite features,
2. choosing countably infinite meanings
3. choosing to disallow uncountably infinite alternatives for scale and component features/meanings.

Was the social consensus non-physical? No

Unless you think minds participating in consensus are non-physical, which I don’t and which the computational view of the mind definitely is not logically allowed to.

Is my computer-changing spilling of coffee non-physical? No.

It is just a gloriously simple example of all the computation-constraining events that are not actually computational.

The pain here is that social consensus foundational for current scientific discourse chose long ago that, if computation was a good way to describe/model natural events, then probably that meant that computation was the language of natural, physical processes. Are models computational? Yes, and that’s exactly why models are, to paraphrase Picasso like all scientists seem to do, “lies that show some of the truth.” That is, it’s the computational compromise of squishing actual facts into the local features to stand in for local meaning that ensures models are limited and biased by our own proposed choices of mappings/encodings. But if that means to anyone that nature is itself a computer, then they have taken the lie to be the truth. And I am sitting here once more with my palm on my face and my head on my desk. [Once more, I can only recommend Pattee who has spent the better part of a century explaining why the success of computational modeling in science has never, ever meant that nature is a computer.](#)

What's tragic is that some of the more intelligent, more qualified critics of computational perspectives on the mind feel compelled to apologize that they might be making a non-scientific point about what the mind is. For instance, immensely qualified computer-scientist Jaron Lanier concedes that okay, okay, his point that the mind is not a computer might sound "metaphysical." I presume that his intended connotation of "metaphysical" is something have to do with God or spirituality, but what this means is that maybe

1. Smart people think that computers are the only physicalist way to describe the mind.
2. Smart people may not consider how the proposed computational perspective on the mind could also require miracles and outright failures of physicalism.

Both options discourage me. And let's be clear here: any computational perspectives on the mind presuming not to appeal to miracle has drastically underestimated what minds can do. Just as Jaron Lanier has pointed out, computers drastically underdetermine the span of actual human behavior.

A more cosmopolitan and inclusive way to think about "metaphysics" might be the philosophers' connotation of the term, which amounts to something like "pre-theoretical assumptions or premises or axioms that you accept without examination or without requiring supporting evidence." I say it might be better because everyone makes pre-theoretical assumptions/premises/axioms—everyone has to. And it might engender some more flattering, respectful discourse if we did not presume to equate anyone else's pre-theoretical commitments with anti-scientific spiritualism.

Cascades are completely physical processes, and the work on multifractal modeling of goal-directed behavior suggests that mind-body-environment relationships pervading psychological experience might just be cascades. Can you model cascade dynamics with a computer? Sure. Does that mean a cascade is a computer? Again, Pattee has been ably reasoning "no" to such conclusions forever.

What I wish folks like Jaron Lanier thought about more often was this:

Computational perspectives on the mind are no less metaphysical than the alternative!

"Well, have you ever considered that maybe the milkshake is a quantum computer?"

I have considered that option, and basically, I don't think the milkshake is any more a quantum computer than it is a non-quantum computer.

I have attempted to stay away from this option like the plague because calling the mind a quantum computer seems to be something that modal psychological discourse attributes to crackpots. I don't actually think that quantum computing is only for crackpots, but I think it's not clear what new options are available with quantum computing that are so good as to think it will be a much better sort of computing to explain the mind.

I met a quantum-computing scholar once. I will not embarrass this person with the responsibility of having given me whatever misunderstanding that this person did not mean to give me—so no names. But this person studied quantum walks as an alternative to random walks. It sounded extremely interesting to me. Wanting to understand milkshakes has led me to learn multifractal geometry, and

multifractal geometry is a gentle elaboration from ordinary variants of diffusion. So, I was intrigued to see an alternative to the random walk as a generating formalism.

The gist of what I understand about quantum walks is the following:

*Whereas **random walks** can only take a step in **one** direction at any single time, **quantum walks** can take steps in **multiple different** directions at the **same single time**.*

Whether or not I have it entirely right, I think that's a really cool mathematical idea. And maybe people who think that the brain or the mind is a quantum computer think that the brain/mind can pursue different trajectories and so consider more options and so, e.g., walk and chew gum at the same time.

But ultimately, [moving in multiple different directions at the same time in goal-directed and context-sensitive ways is what slime mold *Physarum polycephalum* can do](#), and it can do that without being a computer. Can you go ahead and make your computational metaphor for the whole organism of a slime mold? Sure, but I'm not getting on board with that. Making the whole organism into one bigger computer is a good way to enlarge the mystery of what the brain/mind is doing anyway, and besides raising new quandaries about how the non-computer universe generates computer bodies, I see such expansions of the computational metaphor as a good way to help people ignore more of what actually distinguishes the development of goal-directed behavior.

“Okay, so how is the non-computer milkshake faring 10 years later?”

That's a great question. And 10 years in, I can happily report that publishing my work using multifractal modeling of goal-directed behavior has gotten much easier. So, some people apparently see this work as worth reading, and it has been exciting to contribute these ideas in a time when scientific communication has gone digital and so reached new eyes. I am sure that the digital means of communication have lowered the bar on acceptable scientific discourse, and so I don't know how I might have fared in earlier times. So, perhaps my work is part and parcel of a greater tolerance for more material, but it has gotten easier over 10 years, suggesting

1. Digital communication has increased in volume
2. Editors and peer reviewers at journals are more receptive to my multifractal-modeling work.

It's remotely possible that I've gotten better at writing. But I'm only typing this document because I had what might be my last best writing idea ten years ago with the milkshake-acting-like-a-computer. So, let's just write off my writing ability right now.

What I don't see happening much yet is movement in the funding for tenure-track positions for people specifically who have my (or a similarly) unfortunately odd perspective. I have a tendency to publish that has encouraged advisers and spectators to make great prophecies about how many job offers I must get. However, I have only received three phone interviews and three invitations to on-campus interviews in six years of applying to tenure-track assistant professor positions. So, search committees have been distinctly unimpressed with my record. My impression is that research universities want familiar social psychology or cognitive neuroscience. I have seen my colleagues from graduate school with smaller research records get employed and even get tenured. I prefer to presume that I'm just a horrible person and not that my scientific work is so unwelcome and unrecognizable to have no place in academic psychology.

I am quite happy despite the failure of these magnificent prophecies. I am currently very happy to be in my second year of the tenure-track at Grinnell College. However, I arrived here first in a temporary position as a spousal hire. I have been working at a teaching college with generous research funds, and I am immensely happy doing so. It is not the future I planned, it is the present that I love. But when my undergraduate students ask me for advice as to whether they should pursue graduate training, [I have been public about my reservations.](#)

I have been all the more reluctant to press my research students here into the same strange fold of milkshake partisans. Of course, when my students meet my fellow milkshake partisans, it is usually love at first sight that could only come with finding long-lost relatives they never knew they had. Suffice it to say, trying to catch milkshakes in the act of acting like a milkshake is not a career for the faint of heart. I am still here writing to you through this same digital identity because of near-pathological refusal to take private failures to heart.

“Does all of this multifractal modeling mean you can describe what you think in a way that does not require smirky references to milkshakes bashing computers?”

Yes, entirely. The reason that I still greet people with milkshakes acting like computers is that mostly no one cares what I think, and most people do care about computational approaches to psychology. But here goes, and click around through the little outline below if you're as impatient with my text as I am:

[How movement constructs meaning through cross-scale interactivity](#)

[\(What the heck is\) cross-scale interactivity\(?\)](#)

[One more time with feeling: How movement constructs meaning through cross-scale interactivity](#)

[Coevolution: Embodied cognition and then some](#)

[What my work is not: Anatomical](#)

[“\(How\) is what you do still psychology?”](#)

[The challenge to anatomical approaches to psychology: Finite imagination and so far not-finite development](#)

[“Well, okay, but why do your papers go all over the map?”](#)

[“What's with that 'human' stuff above?”](#)

How movement constructs meaning through cross-scale interactivity

Perceptual and cognitive performance thrives on cross-scale interactivity. This interactivity knits together all of an organism's experiences extending across space and time. We can apply known, mathematical estimates to fluctuations in ~~human~~ movement--exploratory or unwitting and unintended.

Why would you ever do that? Well, those known estimates of cross-scale interactivity predict perceptual and cognitive performance. What that means is, more or less, that movement constructs meaning--in a way that is creative and accidental and distributed across, well, more than just the human brain. That's what keeps me up at night, that's what keeps my passions for science burning.

Wait a second, what the heck is "cross-scale interactivity?"

Cross-scale interactivity

Sometimes big stuff changes how little stuff acts. Sometimes little stuff changes how big stuff acts. That second sentence there is more comfortable to more readers: it seems most intuitive that all of the cause and effect of science happens at the fine grain (e.g., with atoms and quarks etc.). The atoms and quarks are wonderfully important, but they are not everything, and they do not have the lock on cause and effect. I could cite some stuff here because the idea isn't mine, but if you find that idea upsetting, then you may have just stopped reading anyway (*buh-bye!*). Zooming up a few orders of magnitude, we can say the same thing about neurons and action potentials. It seems most intuitive that the mind is a brain and so that minds do what brains do, and that brains do what their smallest unit the neuron does.

Neurons do some impressive stuff, but knowing about **neurons** is **not the same thing** as knowing about **all the causes moving the mind**. Neurons make up remarkably little of our bodily tissues, and they follow all the same physics and chemistry governing all of the other tissues. So, maybe they're taking their cues from something other than all of the neurons. Certainly, we know and love the calcium and potassium and sodium ions, those smaller parts, running the show of the action potential, but we don't often talk as much about the taut medium of connective tissue wrapping *around* many/all of the neurons helping them do their thing.

Cross-scale interactivity is that potential that big things might contain small things that make the big things go (which is scientific old news) but that also big things can change how the small things act/look/take shape (which is still old news but maybe less old and certainly less popular). The notion of a "building block" at all, whether it's an atom or a neuron, is somewhat misleading because all of these things are a lot more squishy/ephemeral than in shorthand. Stuff is plastic and moldable, and usually most things are remodeling other things contained by and containing them. It's honestly a mess for anyone hoping to make a nice short list of possible factors and possible outcomes.

This was not my idea, and I am just a lucky heir trying to connect smarter people's dots. Luckily, smarter people than me have spent the past century or so trying to come up with mathematical models of cross-scale interactivity--which is neat for theory--and with statistical methods for estimating interactions across scale--which is neat for empirical science. I am looking here only to get to the point on my own terms. The jargon and the literature review is nice for a kind of specificity with a specific audience, but not here.

One more time, with feeling: How movement constructs meaning

When applied to fluctuations in ~~human~~ movement--exploratory or unwitting and unintended, known estimates of cross-scale interactivity predict perceptual and cognitive performance. What that means is, more or less, that movement constructs meaning--in a way that is creative and accidental and

distributed across, well, more than just the human brain. That's what keeps me up at night, that's what keeps my passions for science burning.

I use models of **cross-scale interactivity** to understand, explain, and predict how **movement gives rise to perceptual and cognitive performance**. I might hedge here and say that, at minimum, cross-scale interactivity addresses the context-sensitive aspects of perception and cognition. That said, I do believe that perceptual and cognitive performance is, by definition, context-sensitive. Perceptual and cognitive performance is not always "right" or "correct" or "rational" or even "good." But I think we only call perceptual and cognitive performance different things from anything else under the Sun because they are context-sensitive in ways that we don't expect other behaviors to be. What looks stable, what looks like a bias, what looks innate only looks that way relative to a very short time scale. I could be wrong about this and would love nothing better but to be corrected, but **very much of what seems stable and rigid and reliable eventually wiggles, wobbles, and falls down if you watch it long enough**. Far from wanting to catch the so-called stable stuff out as a fraud, I think that **the cross-scale interactivity is the eventual relationship between short-term, small-scale wobble and large-scale upheaval**. I think it's also how new structure emerges and how behavior is not just a regurgitation of genetic inheritance.

Coevolution: Embodied cognition and then some

I am not saying that only movement contributes to the mind, but a lot of things that you may not call "movement" show similar statistical signatures, and I do very much suspect that these similar statistical signatures outside the body are far from coincidental. We are co-evolving with a context rich in other organisms building and rebuilding available constraints. Heterogeneity follows quickly from any sort of cross-scale interactivity. The only trick is finding the most appropriate way to quantify the cross-scale interactivity. But at bottom, I think that cross-scale interactivity provides a geometry that makes it easy for us to see where all that lovely texture in perception, cognition, and behavior comes from.

"(How) is what you do still psychology?"

I hope that psychology has room for any attempt to explain how new structure emerges in perceptual and cognitive performance and in behavior. I don't believe that psychology is a commitment to a set of preferred explanatory variables, and I do believe that psychology is a commitment to studying goal-directed behavior scientifically. If you have ever hoped that psychology would explain new behavior, new perception, or new cognition, or at least how any of perception/cognition/behavior changes, then I think that what I do is still psychology. Then again, you are free to set me straight--but I kind of feel like you might have better things to do with your day. But, now, on to what I'll agree my work is not...

What my work is not: Anatomical

I think about my contributions to this scientific conversation as what can be done if we disallow the possibility that anatomical description is everything to scientific explanation. There are many anatomical approaches to psychology that involve identifying independent parts, independent mechanisms usually latent. These accounts vary in how much they align individual mechanisms of the mind with individual mechanisms or individual regions of the brain. These accounts even spend most of their time/effort explaining how minds depend on the interactions of those parts/mechanisms. What I

do is not that. There may be nothing wrong with that approach, and very many people pursue that approach--so many in fact that I feel confident that my reluctance to join in is not causing any great harm. I actually just find this anatomical approach contributes to my own anxiety, which may be entirely on me and my problem.

The challenge to anatomical approaches to psychology: Finite imagination and so far not-finite development

Listing out the many independent parts/mechanisms that play a role may fail either to include everything that ever will play a role OR to explain everything that could happen with a full set of the parts/mechanisms. To the first point: I can barely remember where I left my keys some days, let alone remember all of the different places I could have left them, and so I certainly don't trust myself to imagine and to remember all of the parts/mechanisms that could be under the psychological hood. More than that, new stuff might happen one day.

To the second point: I confess to being romantic enough about the mind being "different from the sum of its parts." I think I am far from alone here, but I do what I do because I do not think that simply believing in the old Gestalt adage is sufficient to balance out doing strictly linear modeling. If we only do linear modeling of our perceptual and cognitive performance, we will only ever have results that allow interpretation as a sum of parts.

Strictly linear modeling vs. modeling cross-scale interactivity

I still run linear models like ANOVAs and t-tests to identify specific effects predicting to perceptual and cognitive performance. That is, to test the usefulness of cross-scale interactivity, I run linear regression models just like ANOVA and t-test to meet the same general standards for statistical significance. I do that because I want to be clear that cross-scale interactivity is not actually better explained (away) by any of the more traditional, usual-suspect variables that I know are more popular.

"Well, okay, but why do your papers go all over the map?"

Well, I'm still learning how to write, and so I am sure I have not been clear. But even if I were to write well, I want to build the argument on many fronts because what I want to say has to borrow from physics and had better make sense to that audience. Then again, because I still think I'm a psychologist, I want to see how well this argument holds up against many different tasks/domains/abilities where psychologists have introduced their computational metaphor to explain what minds do.

I regret the disorganization. But if I'm not 100% wrong that multifractal geometry is a compelling way to understand human behavior, then some unevenness and mess is inevitable to any intellectual pursuit—my scribbling included.

"What's with that 'human' stuff above?"

Oh yeah, I am on a mission against human exceptionalism: we are nifty organisms, and I'm happy to be a human, but I don't think my being human is itself a guarantee of my special status in the world. I want to understand perception, cognition, and behavior in a way that does not need my reaching in and saying that my ability to do X or Y is attributable to my genome. There are a lot of

reasons that would not answer my curiosities. There is a whole world beyond our genomes and our nervous systems, and it is a creative, destructive, and altogether amazing thing.

Misconceptions I'd like to contradict

“Don't you think brains are useless?”

No. I don't. You may know some colleague of mine who are very dismissive of brains. I find dismissal of brains an unfortunate rhetorical move because it upsets audiences too soon without really extending the discourse.

[I do think that brains are not doing as much of what we thought they were doing, and I do think that they're busy doing more of what it hadn't occurred to us needs to happen.](#)

I *do* think it's compelling to see what goal-directed behavior can do, how context-sensitive it can be, and how smart it can look even when there is less (or no) immediate neural basis...whether that's in neuron-free organisms, in organisms with their heads removed or brains detached from their brainstem, or in the context-sensitive responses that are too fast to be neurally supported.

However, none of that is to say that brains are useless. Brains just need to be put in their proper place in a bigger, more populated forest of causes.

“Aren't multifractal analyses just getting us away from seeing the data for what they are?”

Okay, so there is an impression that some readers have that means and standard deviations are “the data” in a privileged way that is free of bias and direct to the heart of the measurement. I don't know whether that's entirely true, though. Means and standard deviations are potentially stable properties that we can estimate when our measurements behave under the constraints of the general linear model. If our measurements have distributions without stable means and/or without stable standard deviations, then no estimate of mean and/or standard deviation is going to be a window onto the data.

Means are supposed to indicate the center of an ordinarily diffusing field of particles. Diffusion is just fancy talk for “spreading out.” Standard deviation is a way to describe how those particles are spreading away from that center in a homogeneous and independent way. Multifractal modeling is a way to describe diffusion when systems spread out in heterogeneous ways, that is when the deviations cannot be relied upon to be “standard.”

“If everything is fractal, doesn't that mean that there is no control condition and so that fractal results cannot tell us anything?”

No. This is a fairly popular misunderstanding. The secret lies in the fact that fractal scaling is a property that resides most clearly in what linear modeling recognizes as standard deviation—not the mean. So, this question comes from a gloomy place of imagining that all things being fractal should make all comparisons null, but I would like to point this question in the following direction comparisons of means should only be *better* when measurements of standard deviations are better aligned.

I might explain it in step-wise fashion like so:

Step 1: If nothing were fractal (let alone multifractal), then everything would be ordinarily diffusive (i.e., with stable mean and stable standard deviation indicating the homogeneous spreading out to equilibrium). Welcome to the universe of entirely ordinary diffusion!

Step 2: Let's ask ourselves now "If everything is ordinarily diffusive, then doesn't that mean that there is no control condition and so that ordinarily diffusive results cannot tell us anything?" To be clear, I am only replacing the word "fractal" in the question just above with the phrase "ordinarily diffusive."

Step 3: Let's recall from our statistics textbooks, that linear modeling (including all t-tests, ANOVAs, regressions, etc.) works best when all measurements are ordinarily diffusive. Ordinary diffusion is exactly what the underlying assumptions for linear modeling aim to specify.

Step 4: So, if everything is ordinarily diffusive, we are in the best possible position to interpret differences detected by linear modeling as effects in our measurements representing causal factors in our manipulations.

Step 5: So, if everything were fractal, then we would just have as even a playing field as if everything were ordinarily diffusive.

Step 6: The good news waiting for everyone is that not everything is fractal or equally fractal. Fractality varies continuously. It is not a simple uniform or binary property. If we replace this question with any number of continuously varying properties like, say, height, we would come up with "If everyone has height, doesn't that mean that there is no control condition and so that measured height cannot tell us anything?" I hope the answer from everyone would be a resounding NO. If people all had the same height or zero height, maybe height would be an uninformative variable, but it's not uniform or binary so it is informative.

Many people do not even think that multifractality is good news yet, though. So, I am surely getting ahead of myself.

"Are multifractal results indicative of the whole system?"

This question often comes from the believers in milkshakes and not the people wondering if all fractal results would mean nothing. However, the answer remains "no."

In short, multifractal results are like any other statistical measure in that they distill out very much of the available information to provide some interesting corner of the information. Averages and standard deviations need "the whole system" for their calculation, and so they speak as well to the "whole system." Multifractal results could likewise be useless if the underlying scaling relationships they need for their definition are not stable.

For what it's worth, I find holism less helpful than anatomies. Anatomies at least make a dutiful effort to inventory the stuff. Holism risks being an empty, hand-wavy narrative that fails to unpack and to explain any of the nontrivial internal texture supporting an organism's goal-directed, context-sensitive behavior.

“I have heard that we don’t have the proper mathematical toolset to make dynamical-systems/complexity/multifractal/cascade-theoretical testable, that our measurements are not the right sort for these analyses at all. Why shouldn’t cascades and milkshakes remain purely metaphors or narratives? I like the narrative but I don’t like or trust the math, and the narrative seems better than the other guys’.”

If you are convinced by the narrative, then go ahead. Tragically or beautifully, you cannot really use any narrative but the one you trust. However, if we avoid using the analytical tests that follow from the theories underlying these narratives, then we risk never convincing anyone but ourselves. I know some people don’t care about convincing skeptics. That’s fine.

As for me, I care about convincing skeptics. Heck, I care even more about making sure I have answered my own skepticism and doubts (*which I have in great supply*). That means that I’m eager to find where the theory breaks, where the analyses might well give us insights for development of those theories, and how soon we can tell the mathematicians where they need to come up with better analyses for the measurements we have.

It’s messy and I’m sure I will have left a trail of mistakes by the time I’m done. But I won’t sit by hoping people listen to my story.

“You must have majored in math to do what you’re doing, right?
Psychologists don’t typically do math.”

Psychology is one of the more quantitatively equipped fields I have encountered. Sure, some people sit on couches and analyze people instead of numbers, but that’s not all of psychology by a long shot.

As for me, I was a psychology major, with a religious-studies minor. I almost finished a math minor, but I didn’t. In any event, I find that the math I do just takes patience and not special training. Much as I am amazed by what multifractal geometry has done and what genius went into its development by the likes of Benoit Mandelbrot and his colleagues, I am no less amazed by how seamlessly multifractal analysis grows out of standard, classical linear modeling.

In that light of seamless growth from linear modeling, we could choose to be dismissive of the intellectual hurdles needing overcoming here. At the risk of being welcoming to more readers and more aspiring modelers, I would like to say that multifractal modeling is an extremely clever, elegant progression of means and standard deviations, iterated enough times to see whether relatively few assumptions of linear modeling hold.

It needed genius to develop multifractal modeling, but we are all lucky that it only needs patience and not genius to master multifractal modeling.

I am a digital-age scholar through and through, yet another milkshake acting like a computer ready for you to click on and read through as you like.

One of the ways that a psychology major can train himself up on multifractal analysis is to have the stupid privilege I had to find my arrogant way to academia and to fall backwards into an abundance of digital access to a newly vast sea of digits devoted to scientific communication.

If anything, when I first wrote about milkshakes acting like computers, I was just stupidly arrogant, White, American, and male to think I could go do anything. And I had a big wide internet at my disposal in which for me to see how much I could learn that was not on my class syllabi. I have learned much more about my limitations and much more about the limitations on that Internet as well as on the people who did not have the access I did. I have been much busier now trying to train up my students (and maybe/hopefully anyone actually reading my scribbles) in the same bravery in going out and trying to discover new things.

The good news is that there appear to be people trying to keep science more open to more people. The bad news is that open science sometimes gets overstated as a utopia of open-arms and acceptance. [We aren't in a utopia here because open science is probably just going to open up new interactions. New interactions that have never happened before might very well end up contentious. It is their novelty that promises a discovery, though.](#) (A reader/once-student/colleague [Charlie Eddy](#) has suggested, a rephrase: "It is there that novelty promises a discovery, though." And I like that too.)

For all of my raillery against computational perspectives on the mind, I'm realizing how much my scholarly identity has taken root in and, perhaps tragically, points back to my stupid little web presence. But I'm hoping that there's more than just tragically local self-reference. I'm hoping I can be an active participant in what has amounted to an exciting dialogue with the world wide web of scholars out there.

The milkshake acting like a computer is an idea that appeared on my stupid professional website ten years ago when I was first struggling to begin a straight-faced professional, academic "web presence.". This little piece here has been an attempt to thank the digital community of scholars that has kept me afloat this far by trying to answer some of the questions and concerns that the sea of digits has thrown my way in a format that is hopefully easier to read and more open to discussion than much of the peer-reviewed literature. I would ask that people read this document in the spirit of open review. And if you have any comments, questions, or thoughts, I'm asking right now for you to please share them to help me make the future of milkshakes acting like computers ever better than the milkshakes past.