FRAMING HUMAN ACTION IN PHYSICS: VALID RECONSTRUCTION, INVALID REDUCTION

By

Shabnam Mousavi and Shyam Sunder

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COWLES FOUNDATION FOR RESEARCH IN ECONOMICS
YALE UNIVERSITY
Box 208281
New Haven, Connecticut 06520-8281

http://cowles.yale.edu/

Framing Human Action in Physics: Valid Reconstruction, Invalid Reduction*

Shabnam Mousavi† (r) Shyam Sunder‡

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Abstract

We propose framing human action in physics before reaching to biology and social sciences, rearranging the order of their usual deployment. As an example, consider efforts to model altruism that start in a frame of psychological or social attributes such as reciprocity, empathy, and identity. Evolutionary roots might also be used by appeal to survival of the species from biology. Only then the modeler abstracts to work on notations, and to establish relationships using mathematical apparatus from physics. This top-down deployment of principles from various scientific disciplines has generated a body of coherent models, partially generalizable theories, and disagreements. In this paper we present a definition of action as a movement between two points in the relevant space, and explore reversing the direction of deploying scientific theories, starting with the principle of least action in physics to frame observed human action. Used as an organizing principle of the whole universe, optimization element in human behavior does not have to be presumed to arise from animate aspects of adaptive and cognitive faculties; emergence of social phenomena, when optimal, can be disconnected from methodological individualism. Our three-tier framework makes room for physical, biological and social science principles, proposing a new perspective on human behavior, sans reductionism.

Keywords: Action, Modeling behavior, Optimization, Physics, Social phenomena.

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† Max Planck Institute for Human Development, Berlin, Germany.

‡ Yale University, New Haven, CT, USA.

The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. (Anderson 1972)

Human beings, on the average and at least in certain circumstances, obey mathematical rules resembling in a general way some of the primitive "laws" of physics. (Stewart 1947)

1 Layering without Reduction

The human mind operates with a neurobiological brain in the physical world. Its sphere of existence comprises many layers that interact in reality yet are considered discrete in theory. Over a century of "scientifizing" economics by engineers and mathematicians has generated a sophisticated reverse-engineering framework for a mechanical analysis and reconstruction of human behavior. Along the way, behavioral economics has been shaped by attempts to augment this rigorous framework with insights from psychology and other disciplines in order to acquire explanatory power for *anomalous* behavior. Anomaly is a generic label for observed actions that do not adhere to the predictions of the theory. The main challenge to expanding this theory such that it can account for anomalies is how to surpass the mechanics of formalization, as integrating the reality of humans comes at the cost of messier mathematics. At the aggregate level, the scene becomes technically much more manageable because the formal assumptions often apply to the average. However, when it comes to policy recommendations and other societal matters involving economists' counsel, maintaining ease of analyses is not implication-free. The problem is not this inherent tandem between clean calculations and force of abstraction from reality, but instead a naïve optimism towards its consequences. A main consequence presents itself in expanding the rules of physics beyond its realm and using mathematical physics for non-physical layers of the animate world, including humans. We maintain that physical analysis belongs to the core shared by animate and inanimate world, and that it can usefully stay where it belongs with a reversal of the order of scientific modeling.

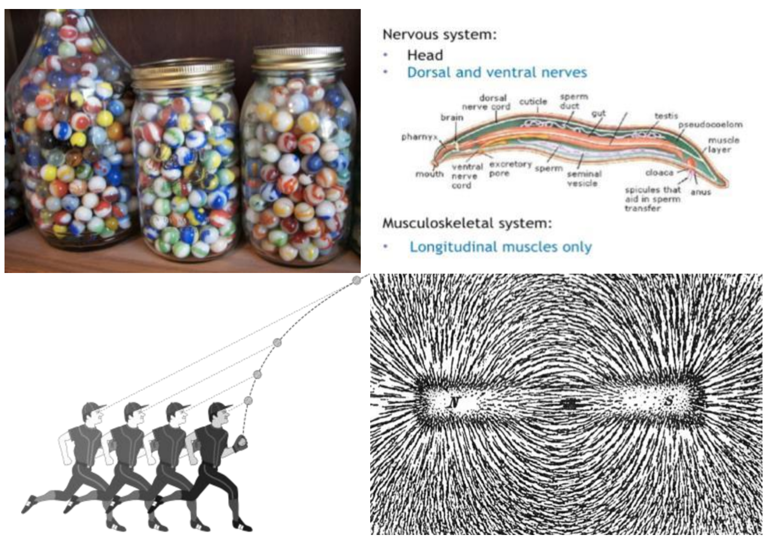
We propose framing human action in physics before reaching to biology and social sciences, rearranging the order of their usual deployment. As an example, consider efforts to model altruism that start in a frame of psychological or social attributes such as reciprocity, empathy, and identity. Evolutionary roots might also be used by appeal to survival of the species from biology. Only then the modeler abstracts to work on notations, and to establish relationships using mathematical apparatus from physics. This top-down deployment of principles from various scientific disciplines has generated a body of coherent models, partially generalizable theories, and disagreements. In this paper we present a definition of action as a movement between two points in the relevant space, and explore reversing the direction of deploying scientific theories, starting with the principle of least action in physics to frame observed human action. Used as an organizing principle of the whole universe, optimization element in human behavior does not have to be presumed to arise from animate aspects of adaptive and cognitive faculties; emergence of social phenomena, when optimal, can be disconnected from methodological individualism. Our three-tier framework makes room for physical, biological and social science principles, proposing a new perspective on human behavior, sans reductionism.

The rest of this paper is structured as follows. In Section 2, we explore both animate and inanimate worlds within the bounds of their shared physical existence; it is not a reductionist approach — we simply ask how much of an action can be defined by simple physics laws before deferring to biology and social science principles. In applying physics' laws to animate phenomena, thinking, intention or meaning need not be operationally considered until the higher human faculties are employed. Section 3 introduces our perspective and a definition of action that we use for illustrative comparisons to the extant method. The advantages of our proposed perspective are discussed in Section 4. Section 5 juxtapose social to physical phenomena and concludes.

2 Optimization: Study domains and subject matter

Is it possible to model diverse phenomena, at least in the first approximation, by a single physics principle, if they all share matter and energy subject to the laws of physics[1]? The pictures in Figure 1 are taken from four different domains and each presents an action, or end point of an action in different areas of study: marbles-filled jars, the nervous system of a nematode worm linking its network of ganglia (nodes), a baseball player running to catch a ball, and iron filings aligned in a magnetic field.

Figure 1: Marbles, nervous system, ball catcher, and iron filings: What do they have in common?



Let us check how far optimization takes us in organizing the phenomena in Figure 1. When a jar is shaken in a gravitational field, the smooth marbles inside approach a local optimum (filling about 64% percent of the space as compared to about 74% global optimal). On connections among the ganglia in a nematode's nervous system, Cherniak[2] writes:

> At multiple hierarchical levels—brain, ganglion, and individual cell—physical placement of neural components appears consistent with a single, simple goal: minimize cost of connections among the components. The most dramatic instance of this "save wire" organizing principle is reported for adjacencies among ganglia in the nematode nervous system; among about 40,000,000 alternative layout orderings, the actual ganglion placement in fact requires the least total connection

> length. In addition, evidence supports a component placement optimization hypothesis for positioning of individual neurons in the nematode, and also for positioning of mammalian cortical areas. (2, p. 1)

How about a player catching a fly ball? In fact, the mere minimization of change in the angle of gaze captures the path the ball catchers have been observed to follow. Cognitive scientists have gathered field data and modeled how animals and humans catch fly balls[3]. The model involves keeping a constant angle of gaze on the ball above the horizon while moving towards the ball until catching it. Note the familiar order in this modeling of action: (1) cognitive attribution (animate aspect): a person catches a ball by deploying the cognitive capability of holding gaze on a moving object against a noisy background; (2) biological attribution (both animate and inanimate): this ability is evolved to serve preys evade predators and predators catch their preys; and (3) physics scheme (inanimate): solving an optimization problem with the objective of minimizing the change in the gaze angle. Orientation of the iron filings fits the magnetic field lines almost perfectly, subject to approximation depending on the size of the filings and friction with the underlying surface. Table 1 provides a classification of subject matter and principles in three broad scientific domains.

Table 1: A schematic of scientific inquiry.[4]

Domain	Animate	Animate-Inanimate	Inanimate
Discipline	Social Sciences	Biology/Molecular Chem.	Physics/Chemistry
Subject matter	Person/group/institution	Cells/Organism/group	Matter and energy
Principles, concepts and terms	Theories of mind Perception & cognition Nature vs. nurture Demand & supply Behavior, labor, capital, trade, contract, judgment, personality, development State and society…	Evolution by natural selection (Matching) Longevity / reproduction Function of organs Anatomy and physiology DNA, RNA, cells, protein, life…	Least action Force fields Chemical binding Inertia & Symmetry relativity Effort, flow, motion, time …
Shared features	Physical existence in all domains is subject to physical laws. Properties (e.g., efficiency) are assessed conditionally.		

Not only starting to analyze from the most visible attributes involved in an observed action is customary, considering the topic in terms of causation and dynamics is too.

Consider this example from a textbook on biology for engineers focusing on *effort* (cause) and *flow* (effect) variables[5]:

> There are two basic kinds of variables that describe the action of a physical system. Effort variables are those things that cause an action to occur. Flow variables are the responses to effort variables, usually involving movement but not always. For the simple case of a running animal, the effort variable is the force required to propel the animal; the flow variable is the velocity of movement. Heat loss from that same animal, which is the flow variable, occurs in response to a temperature difference, an effort variable. Sexual attraction to an animal of the opposite sex (effort variable) can result in a wide range of activities, including copulating (a flow variable). Hunger (an effort variable) can result in feeding (a flow variable). Thus, there are a wide variety of causes and effects related to biological activity, and these can be thought about in terms of effort and flow variables, which tend to simplify the concepts of biological activities. For any activity of a biological organism or system, searching for the effort variable, the flow variable, and relationships between these two can make it easier to comprehend not only how and why the activity occurs, but also the intensity of the activity (5, pp. 32-33).

This effort-flow frame captures the observed phenomena across domains such as force and acceleration in Newtonian mechanics and motivation and work in social sciences. Framed in economics terms, the outcome of sustainability can be achieved by optimizing on the flow variables of consumption and reproduction[6]: "Consumption and reproduction have been and remain the basic values of human societies. These two lie at the root of our moral codes. Even virtue is promoted with the promise of entitlement to more consumption in the future. Development, prosperity and welfare are euphemisms for higher consumption (6, p. 1)."

The conceptual link between economics, arguably the most physical of the social sciences, and physical laws seems rather straightforward, e.g., equilibrium, friction, efficiency; the linkages with other social sciences and with humanities are also present. More than a century ago, Giddings (1906) advocated the path of *least resistance* as the underlying principle of inductive sociology[7]. In the middle of the twentieth century, linguist George K. Zipf[8] built the "biosocial physics" theory of human behavior whose principle of minimum effort derives the well-known eponymous law of probability of words and other phenomena. He considers "mind as a system of mentation" and extends by analogy the philology of semantics in spoken language and cultural preconceptions to the structure of every human action. Such analogical exercises also appear with the concept of inertia that links effort-flow and capacity. Economist Bewley uses inertia to formulate Knight's[9] (another economist) notion of uncertainty [10,11]. Interestingly, inertia represents a fundamental law when it frames cognition in general, as stated by the pragmatist philosopher Ferdinand Schiller (1846-1937)[5]:

> Our curious result of this inertia, which deserves to rank among the *fundamental laws of nature*, is that when a discovery has finally won tardy recognition it is usually found to have been anticipated, often with cogent reasons and in great detail (5, p. 35).

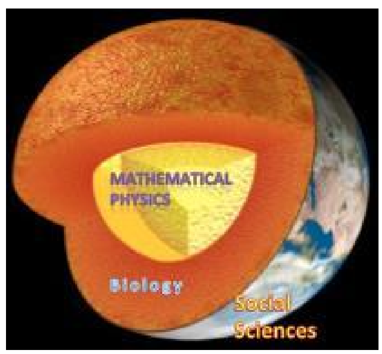
Similarly, cognitive psychologists see "mind as an adaptive toolbox"[12], to bridge Darwinian biology and cognition development. Finally, in socio-physics, the Lagrange principle for probability with constraint that views physics in terms of energy and entropy, is used to frame the subject matter across social sciences, e.g., planned behavior v. spontaneous, or collective v. individual; law as right v. wrong, or order v. disorder; society as bond v. freedom; and economics as ratio v. chances.[13]

3 Direction of moving across scientific tiers for modeling of action

The familiar method of seeking understanding of observed behavior in societies is to specify social-psychological attributes to construct an objective function, specify the opportunity set constraints, and then apply optimization. For example, understanding the price and availability of coffee starts with attributing preferences to consumers, production technology to producers, and opportunity sets to them both, before deriving price and allocations from a model that attributes maximization of their respective goals — utility and profits.

In recent decades, this approach has come under attack from those who take a behavioral approach to economics and argue that humans do not inherently have cognitive capabilities to intuitively solve the complex optimization problems. Perhaps the most common defense of optimization has been that it is only an "as if" assumption, not to be taken literally, and to be justified by documented cognitive abilities and well-specified processes used by economic agents. Thus, behavioral critics use the foundations of mathematical economics that are firmly rooted in methodological individualism[14] to challenge the structure. Perhaps economists yielding to this behavioral critique is the result of modeling from the wrong direction. Let's suppose we start with the universal laws of the inanimate world instead of the obvious social-psychological and cognitive factors. Optimization — the principle of least action (PLA) —is the organizing principle of matter and energy and humans are not exempt. At first order of approximation, we can use the PLA to organize human action, and to seek an understanding of the residual in biological and social sciences respectively. This approach reverses the order of scientific inquiry, and provides a very different, perhaps novel, rationale for optimization to have the first claim on organizing human action, as neo-classical economics means to do.

Figure 2: The three-tier framework for modeling human action. The familiar direction is from the crust inwards, we promote the reverse.



Using the metaphor of the earth's composition, Figure 2 illustrates our three-tier framework using the visual of the earth's core, mantle, and crust. When humans feel warmth emanating from the ground, we attribute it to the earth's crust that we stand on – the most proximate explanation; however, the warmth scientifically emanates from the earth's core. Similarly, the familiar order of human action modeling arises from the simple fact that our social-psychological attributes are most proximate and immediately accessible when in fact deeper precepts are at work.

Reversing the order of modeling and starting with the physics core obviates the need to dwell on our cognitive limitations in optimization; as long as interpretations stay within the bounds of physics, explaining as much as possible of the observed behavior by optimization requires no further justification.

In the animate world, on the other hand, animals' biological attributes should be expected to deviate from the mathematical optimization of physics. Consider the modeling of the foraging behavior of ants[15]:

> It may be hard to judge from field data whether observed [patterns]… represent an optimal foraging strategy according to the unconstrained colony-level cost-benefit criteria outlined in the first theoretical section, or a—not necessarily optimal—byproduct of a fixed decision rule that is adaptive for individual foraging. (14, p. 178)

In the animate world, the fundamental relationships captured by optimization do not necessarily hold:

> Just because something looks optimal … it does not mean it is maximally efficient. Conversely, just because something looks inefficient and suboptimal… it does not necessarily mean it is selected against. That is, there may be unknown or unmeasured benefits at play, or the trait may be expressed rarely and only as a byproduct of individual decision rules that make the system maximally efficient under "normal" foraging… (14, p. 179).

Just as the explanatory power of optimization weakens in moving from inanimate to the animate world, it is reasonable to anticipate that it weakens further when we move to the social-psychological world where the higher faculties of humans (in addition to physics and biology) shape behavior.

3.1 *Modeling action as movement within the bounds of physics*

"Move it!" implies get your act together! We take this meaning literally and use it scientifically. *We define action as a movement between two points*. This working definition is the first in a series in-progress to organize thinking about actions in a general (layered) manner.[16] We invite the readers to use this definition to describe a recent choice they made. If it does not work, try the one before that. And if that does not work either, stop reading further—in your thought experiment, you have already invalidated what is given below.

If you are still reading, think of a subject matter in your discipline. An economist may think about a decision to buy a smart phone, a psychologist may think about emotions and bonds between friends, a biologist about reproduction or mating, and a philosopher about liberty or free will. A physicist may think of virtually any topic. To frame what you thought of as an action in a path generated by moving from point *A* to point *B* in a given state space in accordance with the least action principle, consider this definition:

> *An action is a movement from state A to state B, where A and B are specified by the actor. A pair of beginning-end states (A, B) constitutes a situation.*

The movement of inanimate objects between two points in a given space is a simple example. Notice that an animate actor who catches a ball also conceptually fits in a specified situation, although humans cannot easily figure out the ball's trajectory. The endpoint is both calculable and exogenous to the execution of action - the modeler merely must frame the physical elements of observed behavior using optimization.

Exercise: Framing animate action observables using only inanimate attributes

PLA posits that actions actualize in a way that corresponds to ending at a state of minimum energy. Framing the behavior of catching a fly ball in PLA without drawing on animate attributes entails specification of (1) elements that are external to the optimization problem, i.e., not *acted* on by the actor but taken as given, (2) an action element on which optimization occurs, and (3) a path resulting from PLA that captures some non-trivial aspects of the observed outcome. The beginning point *A,* where the catcher first sights the fly ball, and the end point *B,* where the ball arrives at a catchable, are both external to the action and to optimization, as is the time the ball takes to arrive at the end point. The element of action is the change in the angle of gaze, to be minimized. And the resulting path is a parabola (in vacuum). Table 2 juxtaposes in the same columns the corresponding elements of modeling for the two directions of modeling in the three-tier framework. Also, the final arrangement of the links in the nematode worm's nervous system is decomposed in the same fashion. The latter is an example of a phenomenon from biology (residing in the second tier of our framework) that has animate and inanimate attributes within given boundaries.

Table 2: Modeling catching a ball and the nematode nervous system links.[14]

	Method of modeling	**WHAT: Given variables**	**HOW: Action element**	**Path of Action**
To catch a fly ball	*Current Method: Inward approach with three-tiers*	Time a fly ball takes to reach ~1.5 m above ground	Use the evolutionary capacity of holding gaze on a moving object	A curved path, depending on when the angle of gaze is first fixed
	Proposed method: In the first physics tier only	Same as above	Keep a *fixed angle* of gaze (change=0)	Same as above
Arrange nervous system network	*Current method: Inward approach in the second tier*	Location of ganglia in a combinatorial space	Economize the use of biological resources for connecting (ganglia)	A path of fiber connections with minimal length of connections
	Proposed method: In the first physics tier only	*Number of ganglia*	Minimize distance among ganglia and position them concurrently	*Same as above*

Note that an action does not require that the beginning and/or end point be specified. The definition of action (*an action is a movement from state A to state B, where A and B are specified by the actor)* accounts for several situations (*A pair of beginning-end states (A, B) constitutes a situation*) represented in Table 3.

Table 3: Beginning and end states can be combined by whether or not each is specified by the actor.

A: beginning / ***B***: end	**Specified**	**Non-specified**
Specified	Actions correspond to observable paths (A = B: deliberate inaction)	May never start (wishes and dreams)
Non-specified	Acting under unknowable consequences (Modeling involves reduction)	Habits, customs, rituals (A = B: unconscious inaction)

One of these situations, in cell (1,1) where distinct beginning and end points are both specified in the actor's view signifies physical actions such catching a ball. Interestingly, inaction can be viewed in more than one situation, one of which is where the actor knowingly does not move, that is where $A = B$ in cell (1,1). The other inaction case arises in cell (2, 2) when $A = B$. Notice the general situation in this cell which contains beginning and end points that are not necessarily specified on a conscious level. This situation represents many cases of our individual and societal lives wherein we quietly and habitually act (A different from B) or do not change the status quo (for $A = B$). Other aspects of this simple definition of action, as well as applying PLA to a range of actions from inanimate to animate phenomena have already been worked out[14].

4 Methodological gains from starting the modeling of action in the physics core

Layering of scientific inquiry is not new. Many scientists across fields have used similar metaphors to present their viewpoints on scientific inquiry. Consider these four perspectives.

Social scientist Herbert Simon, whose role in the study and modeling of so many aspects of human behavior is unrivaled, wrote[17] on the structure of science with only an approximate relationship across layers:

> This skyhook-skyscraper construction of science from the roof down to the yet unconstructed foundations was possible because the behavior of the system at each level depended on only a very approximate, simplified, abstracted characterization of the system at the level next beneath. This is lucky, else the safety of bridges and airplanes might depend on the correctness of the 'Eightfold Way' of looking at elementary particles (16, p. 16).

How does this relate to our three-tier framework? Principles in each tier are identified to organize our understanding of the phenomena in that tier as well as in the higher tiers. Thus, the principles of social sciences organize the social phenomena, while principles of biology organize phenomena in biology, but they also may help organize certain social phenomena (e.g., evolutionary theories applied in social domains). Analogously, while principles in inanimate sciences are developed to organize physical phenomena, they may also help to organize certain aspects of biological as well as social phenomena, like optimization. In Simon's graphic skyscraper metaphor, the successive floor of the structure of science supports not only itself but also everything above.

The work that is done within the biological (social) tier follows its own set of fundamental principles; it connects only loosely to the fundamentals of the physics (biological) tier and is in no way a mere derivation of those. Simon is a founder of cognitive psychology[18], one of the highest "floors" of the scientific skyscraper. Taking his observation seriously, we advocate action modeling based on methods that are only partially connected between the tiers, and by interpreting the laws of each tier within its bounds. As such, our perspective agrees with physicist Philip Anderson's characterization of scientific inquiry (which wrought a minor revolution in physics) in his famous article "More is Different"[19]:

> Among the great majority of active scientists, I think it [reductionism] is acceptable without question. The workings of our minds and bodies, and of all the animate or inanimate matter of which we have any detailed knowledge, are assumed to be controlled by the same set of fundamental laws, which except under extreme conditions we feel we know pretty well. … [However] the reductionist hypothesis does not by any means imply a "constructionist" one: The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact, the more the elementary particle physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problem of the rest of science, much less to those of society (18, p. 393).

Anderson goes on to propose a hierarchy of sciences in which each stage has "entirely new laws, concepts, and generalizations." In this hierarchy physiology underlies psychology, but psychology is not "just applied physiology." Psychology itself underlies social sciences, but again, sociology and economics are not just applied psychology. To advance, each science builds its own fundamental principles. We too, think social sciences have their own fundamental principles, which cannot simply be reconstructed from principles of physics or biology. Yet the principles of these sciences, too, are relevant to our understanding of the social phenomena. Our three-tier framework is consistent with Anderson's structure of science in acknowledging a place and role for various sciences with their respective principles, methods and tools. Anderson uses the metaphor of hills and valleys to describe the relationship between adjacent scientific disciplines. Our three-tier framework incorporates both the independence as well as the connections between the adjacent valleys of science.

In economics as well as elsewhere in social sciences, an engineer's approach to building the whole from its parts has appeared in the form of methodological individualism. Thus even when the interest lies in the social (macro level) phenomenon, modeling starts with an individual (at micro level) whose attributes are taken to be shared (hence "representative" agent), so the macro outcomes of the model are results of a constructivist process deriving properties of the aggregate from those of a sophisticated individual, known to economists as the rational agent. The famous economics theorist Kenneth J. Arrow[20] warned about the pitfalls of this common practice:

> In the usual versions of economic theory… seems commonly to be assumed methodological individualism, that it is necessary to base all accounts of economic interaction on individual behavior… A specific version of this has invaded other social sciences, under the name of *rational-actor* models. … [There exists] explicit advocacy of methodological individualism among the Austrian school…[and] useful implications of methodological individualism for positive economics. It is usually thought that mainstream economics is the purest exemplar of methodological individualism [but]…. In fact, every economic model one can think of includes irreducibly social principles and concepts….social variables, not attached to particular individuals, [which] are essential in studying economy or any other social system…(20, p. 8)

The rational-actor model faces two hurdles in scaling up. As the number of agents and their interactions, opportunity sets and strategies increase, analysis of their interactions soon becomes intractable; and simplifying assumptions made to facilitate the task risk loss of important social dimensions. Second, aggregate phenomena often *emerge* from nonlinear complex interactions among many parts, and the properties of such outcomes are not derivable and cannot be constructed from the properties of the parts. How does our three-tier framework fare in this regard? Starting the modeling from the physical "core" towards social science "crust" in our three-tier framework logically implies a way of studying the social phenomenon as an emerged one without discarding the rational-actor element. The rational actor can reside in the physics core, and evolve to the biological mantle, while the social variables and aggregate emerged outcomes in the crust combine to yield insights to human behavior at three different tiers, each with its own principles.

While the use of the laws of physics for modeling human behavior is hardly new, the proposal to start at the inanimate shared layer of all phenomena, before proceeding to biology and social sciences holds a nontrivial gain. For instance, when only the collective outcome of a complex process is of interest, we can use the emergence approach, relegating the specification of individual actors to background, e.g., markets populated with zero-intelligence agents[21]. Because this approach leapfrogs the reconstruction of process by attributing it to the structure, it obviates the need for justifying optimization in formalization of the observed phenomenon. The debate over the role of optimization in modeling human behavior is widespread and ongoing. Objections to the first game theoretic axiomatization of "reasonable" behavior[22] by von Neumann and Morgenstern are well-known. This arguably most influential work in modeling interactions between rational actors stirred a still ongoing effort to validate the scope of axioms of rationality, e.g., in laboratory experimentations[23,24,25], and in theory by posing paradoxes[26,27,28]. The usual defense highlights that optimization is a characterization of the outcome, and not of the process. Examination of descriptive validity of the processes implied by these axioms by incorporating into economics a variety of notions of psychological procedural rationality[29,30] has given rise to behavioral economics[31]. Importantly, however, the behavioral approach to economics preserves the thrust of methodological individualism—an embedded property across behavioral sciences—and thus maintains the pitfall exposed by Arrow[20]. This point is explicitly addressed in the philosophy of science.

The philosopher of science Helen E. Longino, whose innovative angle on objectivity of norms in the scientific practice and its societal consequences including the generation of social knowledge has created new lines of inquiry and discourse, gives a particularly illuminating description of behavioral sciences[32]:

> [T]he question [of behavioral sciences] is why people fall into one or the other of these categories, or fall into a particular range of a multiple-valued quantitative

> (more or less) trait. Behavioral sciences seek to answer this question. Even when the research methodology permits only correlations among behaviors and studied factors, it is intended ultimately to contribute to an understanding of the causes of behaviors. To ask about the causal influences on the expression of a trait in a population is already to be committed to an individualistic point of view….factors maybe genetic, hormonal, neurological, or environmental. The question for researchers is how these factors influence an individual's disposition to respond to situations in one way or another. (31, p. 4)

What will the three-tier framework bring us in this regard? It does not search for causality. Starting from physics does not involve methodological individualism, because it leaves out intention. To see this enhancement, consider the problem of the position of N bodies in the gravitational field. For $N = 2$, mechanical physics will not differentiate between relative changes in the positions between two bodies vs. the changes in one while keeping the other fixed. Now, think of the bodies as two humans. Suddenly, which one moves by how much towards or away from the other connotes a variety of meanings and interpretations associated with potential intentions and goals. In this case, as far as capturing the final positions in a state-space goes, physical laws hold and in the physics core we can configure, explore, and even predict the outcome. To explore beyond geometric positions, e.g., whether the movements were "reasonable", or how to position them initially to achieve a desirable outcome in the end, though, we will need to deploy principles and attributes from higher tiers. This very point has been made in studies that promote interdisciplinary approach to social and statistical physics[33]. In Section 4, a juxtaposition of the physical and social phenomenon in terms of their properties adds clarity to the way in which the practice of core-to-crust directed modeling of action stays beyond issues inherent in the extant direction.

5 Social and physical phenomena in modeling

As is well known in physics, neither modeling nor observation are neutral or mutually independent; they are intertwined in an egg-and-chicken cycle. Historically[34]:

> The scientific observation of the organic world (including humans) went through three stages: first, intensive observation of very small samples (still pursued in primatology); second, statistical observation of large samples to extract averages (still used in much of social science); and third, observation of larger samples that

focused on variability rather than erasing it with averages (striven by Darwin's insight that it is individual variability that drives evolution). All three modes of observation are still very much in use and often complement one another: for example, a puzzling statistical effect may need a more granular ethnographic study to discover the causal mechanisms at work.[35]

In 1947, astrophysicist John Q. Stewart reflected on the state of scientific trajectory of using physical laws to tackle societal problems[36]:

> There is no longer [an] excuse for anyone to ignore the fact that human beings, on the average and at least in certain circumstances, obey mathematical rules resembling in a general way some of the primitive "laws" of physics. *"Social physics" lies within the grasp of scholarship that is unprejudiced and truly modern.* When we have found it, people will wonder at the blind opposition its first proponents encountered.
>
> Meanwhile, let "social planners" beware! Water must be pumped to flow uphill, and natural tendencies in human relations cannot be combated and controlled by singing to them. The architect must accept and understand the law of gravity and the limitations of materials. The city or national planner likewise must adapt his studies to natural principles. (36, p. 485, *emphasis added*)

After 73 years, many social planners and their academic advisors claim to have scientific support from observable cognitive and behavioral attributes for their favored social interventions without careful thinking about support from the physical domain. In doing so, they may incorrectly treat modeling tools as neutral and observations as invariant. Our view of the components of social physics is summarized in Table 4 by a comparison among their properties.

Table 4: Properties of social and physical phenomena

Subject matter / **Scientific inquiry**	**Physical Phenomenon**	**Social Phenomenon**
Observation effect	Yes	Yes
Principle universality	Yes	No
Method neutrality	No	No
Explanatory equivalence	Yes	No

We do not discard the efficiency of social physics for designing social interventions, rather suggest a platform for enhancement. We promote (1) reversing the familiar order of deploying fundamental laws by starting from the physics tier before going to biology and social sciences, and (2) keeping the implications and interpretations of analysis in each tier within the bounds of that very tier by maintain the distinction between animate and inanimate existence. The resulting perspective obviates two issues: criticism associated with methodological individualism embedded in behavioral and social science modeling, and the burden of justifying the use of optimization for problems in animate tiers of existence, such as social-psychological phenomena. Our claim is modest: reducing methodological burdens improves the operation of resulting models, e.g., models of social planning. Both order and observing bounds are particularly of consequence when it comes to extending results from physics modeling to societal implications. It is in this regard that we promote a careful observation of the orders in which scientific insights are produced. Habits are powerful, and conventions are convenient. Scientific practice is no exception to these rules. But, there must be adequate gain from change to occur, evermore pronounced when it comes to the social phenomenon, as vividly verbalized by social philosopher and "policy advisor" Niccolò Machiavelli: "There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in success, than to take the lead in the introduction of a new order in things. (5, P. 51)"

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