Only what exists can cause:
An intrinsic powers view of free will

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This essay addresses the implications of integrated information theory (IIT) for free will. IIT is a theory of what consciousness is and what it takes to have it. According to IIT, the presence of consciousness is accounted for by a maximum of cause–effect power in the brain. Moreover, the way an experience feels is accounted for by how that cause–effect power is structured. If IIT is right, we do have free will in the fundamental sense: we have true alternatives, we make true decisions, and we—not our neurons or atoms—are the true cause of our willed actions and bear true responsibility for them. IIT’s argument for true free will hinges on the proper understanding of consciousness as true existence, captured by its intrinsic powers ontology: what truly exists, in physical terms, are intrinsic entities, and only what truly exists can cause.1

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It matters not how straight the gate,
How charged with punishments the scroll,
I am the master of my fate:
I am the captain of my soul.

William Ernest Henley

1 Introduction

What could be easier than raising my hand if I decide to do so? Yet figuring out what it means to decide among alternatives, to will an action, and to will it freely is not a simple enterprise. Many neuroscientists, psychologists, and philosophers hold that we cannot possibly have free will in a fundamental sense, because in the end, in a causally closed universe, all our actions must be determined by our neurons (and ultimately by our atoms) if they are determined at all and not random. Therefore, they claim, “true” free will is either an illusion or an incoherent notion. We must be content with a practical or social notion of freedom—the ability to decide and carry out an action voluntarily and autonomously, rather than under duress or, say, under the influence of alcohol.

This essay argues otherwise. I can have true free will: I can have true alternatives, true freedom to choose among them, true will to cause what I have decided, and eventually true responsibility. The ultimate reason is that, as a conscious being, I truly exist and truly cause, whereas my neurons or my atoms neither truly exist nor truly cause.

The argument on which these conclusions rest derives from integrated information theory (IIT)\textsuperscript{1,2} and requires coming to grips with what consciousness is and with the ontology that follows from it. It also requires a worked-out notion of what causes what. This essay aims to present the argument as concisely as possible, which comes at a price. We will have to forgo a full explanation of key concepts and to abstain from engaging with the vast literature on free will and its compatibility with determinism.\textsuperscript{3-15} The essay will also not examine the empirical evidence about illusions of free will\textsuperscript{16} and about the ability to predict a subject’s decisions based on brain activity.\textsuperscript{17,18} Nor will it address the cultural, historical, and legal aspects of free will. However, if the thesis that we have true free will is correct, it will have many implications for all of those aspects.

After introducing a simple free will scenario (sec. 2), the essay opens with an outline of the ontology of IIT (sec. 3), complemented by an account of actual causation (sec. 4). A brief overview of the requirements for free will (sec. 5) is followed by the implications of IIT for the existence of true free will (sec. 6). IIT’s “intrinsic powers” ontology is then contrasted with standard substrate ontologies (sec. 7). The essay ends with a discussion of indeterminism and the implications of IIT for freedom, self-changing actions, and responsibility (sec. 8), followed by a brief consideration of experimental tests (sec. 9).

2 A simple free will scenario

To make matters explicit, we will consider a simple but paradigmatic “free will scenario.” Fig. 1 shows four successive experiences I might go through: (1) imagining alternative courses of action, (2) envisioning one or more reasons favoring one action or another, (3) coming to a decision, and finally (4) controlling an action that carries out the decision. Later, the essay will argue that each is an essential ingredient of true free will. Of course, realistic scenarios encompass many variants. For example, I may go back and forth among alternatives and reasons, change my mind, sleep over a difficult decision before taking it, and so on. Other ingredients are also important. For example, the set of beliefs that can influence a decision may be small or large, shallow or deep; they may involve notions of the self and autobiographical memories, and include innate or acquired values. As we will see, the broader one’s understanding of the context of a decision, the more free will can be exercised. As we will also see, freely willed decisions can change who we become as well as the world around us, all of which will progressively increase our responsibilities.

| alternatives | reasons | decision | control |
|--------------|---------|----------|---------|
| self, beliefs, values | “I could do this or that.” | “I will do this.” | “I am doing it.” |
| | “I should do this because…” | |

Figure 1. A paradigmatic free will scenario. Each of the four experiences depicts a key ingredient leading to a freely willed action.
3 Ontology: an experience as a Φ-structure unfolded from a complex

The critical starting point is a proper ontology: a principled, coherent notion of what truly exists when I, as a conscious subject, consider alternatives, reason, decide, and execute an action. In other words, before deciding whether true free will can exist or not, we need a theory of what consciousness is and what it takes to have it. This requirement is not exclusive to free will—for example, meaning, too, can only be understood on the basis of a theory of consciousness. But it is especially acute in the case of free will because, as we will argue, only what truly exists can cause.

This paper relies on the ontology of consciousness proposed by IIT. If IIT is correct, as can be established through empirical tests, it has critical consequences for free will. The bare bones of IIT will be sketched below, and only to the extent that they are required for the argument. A proper introduction can be found elsewhere.3, 2, 19

3.1 Phenomenal and physical existence

IIT addresses the problem of consciousness starting from phenomenology—the existence of my own experience, which is immediate and irrefutable—rather than from the behavioral, functional, or neural correlates of experience.

The first step is to realize that the experience I am having, here and now, exists. When I come into being, say, awakening from a dreamless slumber, my very experience demonstrates that there is something, not nothing. Phenomenal existence is IIT’s 0th axiom because there is no more fundamental and certain starting point. As recognized by Descartes and others, the existence of experience is given immediately—it is not something I infer from other evidence. And it is irrefutable, because even doubting is an experience, thus confirming the validity of the axiom.

It is critical to recognize the ontological primacy of phenomenal existence, but it does not lead very far by itself. There are countless regularities in my experiences, and they cry out for a good explanation. For example, I am confident, here and now, that the scene I am experiencing is the same as the one I remember experiencing before I closed and reopened my eyes. I am convinced, here and now, that my hands remain attached to my body no matter how I move them, and so on. To account for these feelings of regularity and invariance, we make countless inferences to a good explanation, whether we realize it or not. The most fundamental of these are codified in IIT as realism, physicalism, and atomism.

Realism assumes that there are “things” that exist independent of my experiencing them, and they persist even when, for example, I fall asleep and cannot interact with them. Physicalism assumes an operational criterion for assessing the existence of things outside of my own experience: I can be confident that something exists—whether it is my hand, a rock, a distant star, or an elementary particle—if I can show or infer that it has cause–effect power, in the sense that it can “take and make a difference,” and it does so in a way that is reliable and persisting. Atomism (operational reductionism) assumes that ideally, to leave nothing out, an explanation should start from the smallest units that can take and make a difference.

Based on these assumptions, IIT introduces its 0th postulate or “principle of being”: to exist in physical terms means to have cause–effect power—being able to take and make a difference.1 In other words, physical existence is defined purely operationally, from the perspective of a conscious observer, with no residual “intrinsic” properties (such as mass or charge).2 Furthermore, physical existence should be conceived of as cause–effect power, all the way down—namely down to the finest, “atomic” units that can take and make a difference.3 Ideally, one would then obtain an atomic transition probability matrix (TPM) that reflects the conditional probability of how the state of every elementary unit of cause–effect power responds to manipulations of the state of any other set of units.

From these foundations, IIT accounts for consciousness in the following way. We first use introspection and reasoning to identify the essential properties of consciousness—the axioms of phenomenal existence. We then consider what could account for each axiom in terms of cause–effect power; that is, we formulate an essential phenomenal property into an essential property of the substrate of consciousness—yielding the postulates of physical existence. In this way, we obtain a set of criteria that allow us to identify and characterize a substrate of consciousness (say, a set of cortical neurons). These steps are summarized in brief below and in fig. 2.

3.1.1 Axioms: the essential properties of phenomenal existence

Using introspection and reasoning, one can identify five essential properties of consciousness—namely, intrinsicity, information, integration, exclusion, and composition. These are known as the axioms of phenomenal existence:

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1 The principle of being is related to the Elatic principle expressed in Plato’s Sophist. The Elatic principle says that for something to exist, it must take or make a difference, whereas the principle of being says that to exist something must take and make a difference.

2 This common use of the term “intrinsic,” referring to a property that “inheres” to a substrate, is different from the use in IIT, where intrinsic means “for itself,” “from within.” According to IIT, what one can assess operationally are ultimately just conditional probabilities (“if I do this, I see that.”) This also implies that all “categorical” properties (what something is like) are ultimately “dispositional” (what powers something has).

3 Fundamental physics is open about ultimate constituents (elementary particles as opposed to fields) and about the discrete or continuous nature of the universe. From first principles (operational cause–effect power), IIT assumes discrete micro-units, micro-updates, and micro-states.
**Intrinsicality** means that experience is *intrinsic*: it exists for itself. In other words, it exists from the intrinsic perspective of the experient, from within. Thus, when I experience the scene in front of me, the scene is for me, and experienced from inside, rather than for somebody else, from outside.

**Information** means that experience is *specific*: it is this one. I cannot conceive of an experience that would not be the one it is, but generic. And while it could be some other specific experience, when I experience it it would be again be “this one.” Because an experience is always this specific one, it also differs from a large repertoire of other possible experiences, a property called *differentiation*.

**Integration** means that experience is *unitary*: it is a whole, irreducible to separate experiences. Thus, the scene cannot be reduced to a left side and a right side that are experienced separately; if it were so, there would be two independent consciousnesses rather than one.

**Exclusion** means that experience is *definite*: it is this whole. It has the content it has and the grain it has—not less nor more. For example, my visual experience has a border: it includes all the visual field—its left and right side. It excludes my experiencing less—say, the left side only but not the right side—and my experiencing more—say, a periphery that extends to the back of my head.

**Composition** means that experience is *structured*: it is composed of phenomenal *distinctions* and the relations that bind them together, yielding a phenomenal structure that feels the way it feels. For instance, I can distinguish a body, a hand, and a book; the hand is attached to the body and lying on the book.

These five properties are called *axioms* because they are immediate and irrefutably true of every conceivable experience. They are immediate in the sense that they are evident without requiring any inference, and they are irrefutable in the sense that it is impossible or absurd to conceive of an experience that lacked them. Thus, I cannot think of an experience that is not for me—the subject of experience—that is not specific, not unitary, not definite, and does not have any content.3

### 3.1.2 Postulates: the essential properties of physical existence

If every experience is characterized by these five essential properties of phenomenal existence, the substrate of consciousness should be characterized by the same properties in terms of physical existence, understood operationally as cause–effect power. IIT thus formulates the five phenomenal axioms as five physical *postulates*:

**Intrinsicality** means that substrate of consciousness must have *intrinsic* cause–effect power: it must take and make a difference *within itself*. Every unit outside the substrate of consciousness is then considered a *background condition*. Also, cause–effect power must be assessed from the intrinsic perspective of the substrate—relative to it.

**Information** means that the substrate of consciousness must have *specific* cause–effect power: it must be in *this state* and select *this cause–effect state*. The selected state is the one that maximizes intrinsic information (ii).

**Integration** means that the substrate of consciousness must have *unitary* cause–effect power: it must specify its cause–effect state as a whole set of units, irreducible to separate subsets. Substrate units, too, must be irreducible. Irreducibility is measured by integrated information (I) over a substrate’s minimal partition, which serves as a quantifier of integrated existence (how much something exists as one thing).

**Exclusion** means that the substrate of consciousness must have *definite* cause–effect power: it must specify its cause–effect state as *this whole set of units*. This is the set of units that is maximally irreducible, as measured by maximum Φ (Φ∗). This set is called a *maximal substrate*, or *complex*. Note that the units themselves must be maximally irreducible within.

**Composition** means that the substrate of consciousness must have *structured* cause–effect power: subsets of units must specify cause–effect states over subsets of units (distinctions) that can overlap with one another (relations), yielding a cause–effect structure, or Φ-structure, that is the way it is.

A substrate of consciousness—say, a set of neurons in the cerebral cortex—must comply with all postulates. In principle, we can check this by obtaining a complete TPM of the system—an overview of how its units respond to all possible perturbations of their state, given certain background conditions. From the TPM, we can determine which set of units constitutes a complex and *unfold* all its causal powers—its Φ-structure. A complex specifying a Φ-structure satisfies, in physical terms, all the essential properties of phenomenal existence and should be considered an *intrinsic entity*—one that exists intrinsically, for itself. And just as experience truly exists—as we know immediately and indubitably—an intrinsic entity should also be considered as truly existing.

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3 Here, “me” should be understood simply as the subject of experience, not as a separate entity that does the experiencing, even less as a self in a conceptual or autobiographical sense.

4 States of “pure consciousness,” “pure presence,” or “naked awareness” are sometimes described as “contentless” because subjects who can achieve them experience no objects, no self, and no thoughts. However, subjects do experience something akin to a vast expanse, often described as “luminous,” which is indeed a content, structured in a specific way.

5 This is a measure of intrinsic difference that can be shown to capture uniquely the postulates of existence, intrinsicality, and information. A key property of this measures is that it is sensitive to a *tension between expansion and dilution*.

6 Units must be maximally irreducible within with respect to their grain. This includes the unit grain, that is, the relevant units for causal observations and manipulations, whether they be proteins, synapses, dendrites, or other sub-cellular compartments; neurons, groups of neurons, or columns; and so on. The term also includes the *update grain*, the relevant timescale of the causal operations, whether tens, hundreds, or thousands of milliseconds, and the *state grain*, the relevant repertoire of states, whether two (ON or OFF), four (say, no firing, low, high, and burst firing), or more.
My experience exists, immediately and indubitably. Based on its regularities, I infer the existence of a world independent of me. I call it “physical” if I can operationally observe (eye) and manipulate (hand) the states (uppercase ON, lowercase OFF) of a substrate (e.g., a brain) whose units can “take and make a difference.” This yields conditional probabilities (right) that capture its cause–effect power, summarized by a substrate model (left).

Just as my experience exists for itself, its substrate must have cause–effect power for itself. The dotted blue line on the substrate (left) indicates a candidate substrate (aB) whose causal powers may be analyzed within itself as a transition probability matrix (TPM, right), with background conditions (C) fixed (pin).

Just as my experience is specific, its substrate, in its current state (aB), must select a specific cause-effect state (s' = {Ab, Ab}, cause in red, effect in green). This is the state that maximizes intrinsic information (ii) for the substrate as a whole. And just as my experience, being specific, is different from countless other experiences, so is the cause–effect state specified by other states of the substrate (e.g., Ab and AB).

Just as my experience is unitary, the cause–effect power of its substrate must be unitary. If so, partitioning the substrate (e.g., unidirectionally between unit a and unit B, left) must reduce the intrinsic information it specifies (shown on the TPM, right). The irreducibility of the cause–effect state specified by the substrate as a whole to that specified by separate parts—how much a substrate exists as one substrate—is measured by integrated information (\(\Phi\)).

Just as my experience is definite, the cause–effect power of its substrate must be definite. By the principle of maximal existence, the border of the substrate of consciousness (a complex) is the set of units that exists the most (here, aB, for which \(\Phi\) is maximal), excluding all overlapping sets (e.g., a and aB).

Just as my experience is structured by distinctions and relations, the cause–effect power of the complex must be structured by distinctions and relations specified by subsets of units over subsets of units (right). Distinctions (black) link a cause (red) and an effect (green) through a mechanism. Relations (shades of blue) bind distinctions whose causes and/or effects overlap. Together, distinctions and relations compose the cause–effect structure “unfolded” from a complex (left).

Figure 2. ITT’s axioms of phenomenal existence and postulates of physical existence.
3.1.3 The explanatory identity: An experience as the Φ-structure unfolded from a complex

On this basis, IIT asserts an explanatory identity: an experience is identical to the Φ-structure unfolded from a complex. In other words, all phenomenal properties of an experience—its quality or how it feels—are accounted for in full by the properties of the cause–effect structure unfolded from a maximal substrate, with no additional ingredients (fig. 3). Thus, all the contents of an experience here and now—including spatial extendedness; temporal flow; objects; colors and sounds; thoughts, intentions, decisions, and beliefs; doubts and convictions; hopes and fears; memories and expectations—correspond to sub-structures in a cause–effect structure (Φ-folds in a Φ-structure). Moreover, the sum total of the φ values \( v \) of the distinctions and relations that compose the Φ-structure measures its structured integrated information \( \Phi \) (“big Phi”) and corresponds to the quantity of consciousness—the content of an experience. And just as a Φ-structure, corresponding to an experience as a whole, can be said to truly exist, the sub-structures within it, corresponding to contents of the experience, can be said to truly exist within the experience.\(^v\)

The validity of IIT as an account of consciousness can be assessed by considering its ability to explain and predict both the presence of consciousness and its content in the one case we are sure of, our own experience and our own brain. Regarding the presence, we can assess whether brain areas thought to contribute to the neural substrate of consciousness comply with the postulates, whereas other areas do not. For example, posterior cortical areas are organized as a set of grids stacked upon one another in series and in parallel, linked by converging and diverging connections, an arrangement that is well suited to high values of \( \Phi \). And indeed, both neurological and neurophysiological evidence, obtained through lesion, stimulation, and recording studies, indicates that posterior cortex likely constitutes the bulk of the neural substrate of consciousness,\(^{21, 22}\) By contrast, brain regions such as the cerebellum, which has many more neurons than the cortex and is indirectly connected to it but is characterized by a modular, feed-forward anatomy, can be lost due to tumor, accident, or surgery without affecting consciousness directly.\(^{23}\) IIT also predicts that the neural substrate of consciousness should cease to satisfy these properties when consciousness vanishes, as is the case in dreamless sleep or under anesthesia. This prediction has been confirmed by clinical studies showing that the efficacy of causal interactions within the cortex breaks down when consciousness is lost.\(^{24, 25}\)

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\(^v\) The irreducibility of the distinctions \( \phi \) and relations \( \rho \) that compose the Φ-structure measures how much each of them exists within the experience.

\(^{19}\) In fact, according to IIT, even contents such as abstract concepts (truth and beauty, values and norms, numbers, and propositions), only exist as sub-structures within individual minds, and nowhere else.\(^{19}\)
Regarding the quality or content of consciousness, the explanatory identity of IIT predicts that the $\Phi$-structure unfolded from the neural substrate of consciousness should account for the particular properties of specific experiences. 

*Extensions*—cause–effect sub-structures unfolded from neural units connected in a grid-like manner, such as topographically organized areas of posterior cortex—can in principle account for the phenomenal properties that make spatial experiences feel extended.26 *Flows*—cause–effect sub-structures unfolded from directed grids (as opposed to undirected ones)—should account for the phenomenal properties that make time feel flowing.27 *Conceptual hierarchies*—cause–effect sub-structures unfolded from pyramids of grids in posterior cortex—should account for the experience of objects, and so on for all other modalities of experience.

### 3.2 The principles of maximal and minimal existence

The information and exclusion postulates select the cause–effect state and the substrate of consciousness by invoking the *principle of maximal existence*, which plays a central explanatory role in IIT. In short, the principle says that, with respect to a requirement for existence, *what actually exists is what exists the most*. Thus, with respect to exclusion, the principle provides a sufficient reason for why an entity that actually exists has the border it has rather than different borders (which would make it a different entity). For IIT, *existence itself should be the reason* among a set of entities “competing” for existence over the same substrate, the entity that actually exists should be the one that lays the greatest claim to existence. Because what defines the quantity of integrated existence is *irreducibility* ($\phi$), the entity that actually exists is the one that has the highest value of $\phi$ ($\phi^*$. By the same token, candidate entities overlapping over the same substrate but with lower $\phi$ are excluded from existence.28

In principle, to find out which entities exist intrinsically through observations and manipulations, we would have to measure the irreducibility of all candidate units (grains, updates, and states) and all candidate entities, for all possible partitions—over a universal substrate. In practice, assessing maxima of $\phi$, exhaustively is out of the question, and one must resort to various approximations and simplifying assumptions. However, what exists maximally neither can nor needs to perform such exhaustive measurements—it does not need to “throw its weight around” to find out whether it should exist—whether it is indeed a maximum of irreducible, specific, intrinsic cause–effect power, and what its $\Phi$-structure might be. By the principle of maximal existence, only maxima of existence actually exist.

The principle of maximal existence implies what can be termed a principle of no free existence: cause–effect power cannot be multiplied over the same substrate. For example, assume that the neural substrate of consciousness—the “main” complex in our brain, turns out to correspond to a set of neurons encompassing primarily posterior cortical areas (blue outline in *fig. 3*). Then, what exists here and now in physical terms is the $\Phi$-structure specified by this main complex in its current state (the large $\Phi$-structure depicted in *fig. 4*). And if the full cause–effect power of this main complex in posterior cortex corresponds to the large intrinsic entity that is my current experience, no further entities can co-exist over the same substrate. There cannot *also* exist some other entity corresponding, say, to one half of posterior cortex, or to one particular area within it, or to the entire cerebral cortex, or, say, to the entire brain. Otherwise, the full cause–effect power of a substrate would be multiplied “for free.”

In other words, the full cause–effect power of the substrate of consciousness cannot co-exist with those of its subsets, supersets, and parasets (exclusion for sets). Instead, what can also exist are other intrinsic entities, likely small, whose

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26 The same principle of maximal existence is applied to distinctions and relations, as well as to the grain of units, updates, and states, excluding from existence alternative entities over the same substrate. The irreducibility $\phi$, being based on a measure of intrinsic difference, is sensitive to a tension between expansion and dilation.28 For example, given certain parameters characterizing a substrate (including the strength of the connections among the units and their topology, the internal mechanism of the units, and the amount of indeterminism), the size of the entity of maximum $\phi$, will typically be intermediate between individual units and the entire substrate.

27 These are sets that include some units within the substrate and some units outside of it.
substrates do not overlap with the main complex. These many small \( \Phi \)-structures are mere ontological “dust” (fig. 4)—unfolded from, say, groups of neurons arranged in partially segregated loops in prefrontal areas or in the cerebellum. Similarly, the units that constitute the main complex (corresponding, say, to neurons) whose cause–effect power is unfolded into the entity’s \( \Phi \)-structure, cannot co-exist with finer units (organelles, proteins, atoms) or coarser units (minicolumns, voxels, regions), because their cause–effect power would be multiplied for free (exclusion for grains).

The principle of maximal existence is complemented by the principle of minimal existence. The principle states that, with respect to an essential requirement for existence, nothing exists more than the least it exists. The principle is offered by IIT as a good explanation for why, given that a system can only exist as one system if it is irreducible, its degree of irreducibility should be assessed over the partition across which it is least irreducible (the minimum partition). Moreover, a set of units can only exist as a system if it specifies both an irreducible cause and an irreducible effect, so its degree of irreducibility should be the minimum between the irreducibility on the cause side and on the effect side (as shown in fig. 2). Similarly, a distinction within a system can only exist as one distinction to the extent that it is irreducible, its degree of irreducibility should be assessed over the partition across which it is least irreducible, and it should correspond to the minimum between the cause and the effect side.

3.3 Intrinsic entities, extrinsic entities, and the great divide of being

We have seen that only a maximally irreducible substrate that unfolds into a \( \Phi \)-structure—an intrinsic entity—can account for the essential properties of phenomenal existence in physical terms. What must be emphasized now is that only an intrinsic entity can be said to exist intrinsically—to exist for itself, in an absolute sense. By contrast, if something has cause–effect power but does not qualify as an intrinsic entity, it can only be said to exist extrinsically—to exist for an external observer, in a relative sense (table 1). And intrinsic, absolute existence is the only existence worth having—what we might call true existence. Said otherwise, an intrinsic entity is the only entity worth being.

To see why, imagine a world without any large intrinsic entity—a world in which every conscious being had fallen into dreamless sleep, or a world in which all conscious beings had died off, or the “early” universe as currently conceived, prior to the existence of stable planets that permitted life to evolve. In such a world of ontological dust, where nothing would feel like anything much, nothing would exist for which it would be true that something exists. In such a world, what would existence even mean? Schrödinger put it well: such a world would be “a play before empty benches, not existing for anybody, thus quite properly speaking not existing.” The existence of something would be an inference nobody could draw, rather than an immediate and indubitable truth somebody would experience. Between intrinsic and extrinsic existence, then, passes the most fundamental of divides—the great divide of being. This is the divide between what truly exists in an absolute sense, in and of itself—namely conscious, intrinsic entities—and what only exist in a relative sense, for something else.

Substrates that do not unfold into intrinsic entities are merely “stuff”; they are substrates that can be observed and manipulated but that do not specify maxima of cause–effect power and thus only have extrinsic existence. Stuff can range from assortments of macro- or micro-units that do not “hang together” (a random sample of air molecules), to aggregates that hang together loosely (an avalanche) or tightly (a rock).xiii Indeed, not all the stuff that fails to qualify as an intrinsic entity is created equal. Things—stuff that hangs together tightly—can be considered extrinsic entities. These are substrates whose causal powers have high values of \( \varphi \)—higher than most of their subsets, supersets, and par gaps—but they are relative maxima of cause–effect power rather than absolute maxima.

For example, my body hangs together well; it is a paradigmatic case of an “organism” that works as a unitary whole rather than as a set of isolated organs. It should thus have higher \( \varphi \) than most of its subsets (say, my body minus some random assortment of organs), supersets (my body plus some garments), and parasites (my ears plus my shoes). However, if IIT is right, my body must be a relative maximum of \( \varphi \), and inside my skull there must be a much higher, absolute maximum of \( \varphi \) that is specified by the substrate of my current experience, presumably located within posterior cortical regions within my brain. This absolute maximum is an intrinsic entity and thus excludes my body from the realm of entities that exist truly and absolutely, for themselves. In other words, since my body is a superset of my main complex, it is excluded from it—relegated to the realm of entities that only exist relatively, for an observer who can verify that they indeed hang together.

Bodies and organs, tables and rocks, stars and planets, and many other things that seem to hang together well are likely to unfold into extrinsic entities. Many objects of study in the special sciences, such as molecules, organelles, cells, organs, organ systems, organisms, groups, societies, and the like, which have proven to be good ways of carving nature at its joints, are also likely to correspond to relative maxima of \( \varphi \). No matter how well extrinsic entities hang together, they do not exist for themselves. They only exist vicariously, from the perspective of some intrinsic entity, and so they do not truly exist. If I fall into dreamless sleep, my body will be breathing,

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xiii Collections of things that do not hang together extrinsically may still make sense from the point of view of a conscious observer (say, the set of unread books in Scandinavia), in whose mind they hang together as a highly interrelated content of experience.
my heart pumping, but in a fundamental sense, there will be nobody there—in fact, not even a body—just an aggregate of much smaller entities. Yet for my conscious friend observing it, my body will continue to exist just as much as it did before I fell asleep.

3.4 IIT’s intrinsic powers ontology versus extrinsic substrate+ ontologies

As we have seen, IIT starts from phenomenal existence and defines physical existence operationally in terms of cause–effect power “all the way down,” with no intrinsic residue, such as mass and charge. Accordingly, a substrate should not be thought of as an ontological or “substantial” basis—an ontological substrate—constituted of elementary particles that would exist as such, endowed with intrinsic properties. Said otherwise, existence is not constitution (here in the sense of the physical makeup of something, table 1).

Instead, a substrate should be thought of as an operational basis—an operational substrate—from which we can unfold causal powers to reveal what actually exists. And what actually exists—according to the postulates of physical existence, based in turn on the axioms of phenomenal existence—are cause-effect structures unfolded from non-overlapping, maximally irreducible substrates, at a grain that maximizes irreducibility. Each complex is an intrinsic entity, fully characterized by its Φ-structure, that truly exists because it exists for itself—it exists absolutely as a conscious being (fig. 5A). In short, the actual is the potential, in the sense that what something is (the actual) is given by its powers (the potential).

This view we will call the intrinsic powers ontology of IIT. It differs from the assumptions usually taken for granted in neuroscience and biology, which we will call extrinsic substrate+ ontologies (fig. 5B). These ontologies are extrinsic because any convenient set of units, at any convenient grain, can be considered to exist (although the “microphysical” level is

Figure 5. IIT’s intrinsic powers ontology vs. extrinsic substrate+ ontologies. Left side: In IIT, what truly exists is not a substrate as such (e.g., a brain) but rather the fully unfolded intrinsic causal powers of a maximal substrate, captured by a Φ-structure (top left). The substrate as such does not exist intrinsically but only extrinsically—as an operational basis that one can observe and manipulate (bottom left, faded gray brain). A Φ-structure can be “vertically” determined from the substrate (e.g., by a researcher), but not determined by it; the maximal substrate unfolded into a Φ-structure is what truly exists because it exists intrinsically. Right side: The ontology of IIT stands in contrast with various views, here bundled together as extrinsic substrate+ ontologies. These typically view the microphysical substrate as ontologically fundamental (bottom right, colored brain), governing the vertical “emergence” of higher-level properties and constructs (top right). Functional states are thus ultimately determined by the microphysical substrate. Such states can be described as “real” inasmuch as they are necessary for explanation and are not reducible to the substrate owing to “multiple realizability,” yet the microphysical substrate as such remains the ontological bedrock.

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Presumably, none of these small intrinsic entities will be conscious in a way that feels like much at all.
typically considered more fundamental); brains exist, and within them different brain regions; neurons exist, and within them organelles and proteins; atoms exist, themselves constituted of elementary particles. Moreover, these extrinsic ontologies assume an ontological substrate because substrates are thought to exist as such, as an ontological basis endowed with fundamental physical properties, such as mass and charge, and following the “laws of physics.”

A substrate only view would argue that all that exists is in fact the physical substrate (the Lucretian universe of “atoms and the void”), dismissing consciousness as “illusory.” More common are substrate+ views which hold that, in addition to the physical substrate, some kind of existence should be granted to properties and constructs, especially functional ones, that may “emerge” upon that substrate (hence the “plus”). These emergent properties and constructs are considered “real” for two main reasons. First, they are necessary for us to understand what organisms do (and, more generally, to understand any complex system). Second, the same emergent properties can be realized by multiple microphysical configurations, which makes these high-level properties not reducible to their specific substrate. Thus, functions such as imagination, reasoning, and decision-making are granted existence because our behavior can only be explained by resorting to such constructs and because they may be realized differently in different brains (or even in computers). In substrate+ views, therefore, microphysical substrates exist as such, but high-level properties also exist in their own right, albeit in a less fundamental sense because they require the substrate to emerge.

The contrast with IIT’s intrinsic powers ontology is fundamental. By IIT, when I am conscious, what actually exists is a complex unfolded into a large Φ-structure, corresponding to my experience, and it exists at its particular grain. No subsets, supersets, or parasets of that complex also exist, just as no other grains also exist. Moreover, what actually exists is only the complex unfolded into a Φ-structure corresponding to my experience, not also a substrate as such. Crucially, any content of my experience, including alternatives, reasons, and decisions, corresponds to a substructure within my Φ-structure, not to a functional property emerging from my substrate.

This has an important consequence for free will: because I actually exist—as a “large” intrinsic entity—the neurons of my complex cannot also exist. They cannot exist as constituents of my complex, because what actually exists is not a substrate as such but the substrate unfolded into a Φ-structure expressing its causal powers. And they cannot exist as small intrinsic entities in their own right because, if they specify a large intrinsic entity, they cannot also specify a set of smaller entities. Moreover, because my alternatives, reasons, and decisions exist within my experience—as sub-structures within an intrinsic entity—the neuronal substrates of alternatives, reasons, and decisions cannot also exist. If this picture is correct, it leaves no room for emergence or dualism of any sort.

### 3.5 Existence and “vertical” determination

Despite their fundamental differences with respect to what actually exists, both IIT’s intrinsic powers ontology and extrinsic substrate+ ontologies rely on what will be called vertical determination, albeit in two very different senses—operational and ontological. A Φ-structure can be fully and uniquely determined from a substrate of units in a specific state through a set of observations, manipulations, and calculations (by, say, a researcher). In this operational sense, the Φ-structure can be unfolded “vertically” from the substrate’s TPM based exclusively on the postulates of physical existence—no further ingredients needed (fig. 5A). What actually exists is the substrate unfolded into a Φ-structure, because the substrate does not exist as such.

In extrinsic substrate+ ontologies, all emergent properties and constructs are fully and uniquely determined by the microphysical substrate in an ontological sense (fig. 5B). The emergence of high-level properties can be accounted for vertically by the properties of the substrate—no new physical properties or laws needed. Emergent properties and constructs exist—they are “real”—because they are not reducible to their substrate due to their explanatory role and their multiple realizability. The substrate actually exists as such; in fact, it must exist for irreducible high-level properties to emerge—to also acquire some kind of existence.

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xvi There is a variety of opinions about the status of phenomenal properties and their association with functional properties, including the idea that they may be “illusory.”

xviii The notion of vertical determination here is related to supervenience: an experience can be said to supervene on a microphysical substrate (its supervenience basis), in the sense that any difference in the former is necessarily reflected in a difference in the latter. Either way, a substrate or supervenience basis are not assumed to exist as such but only as an operational basis from which what truly exists can be unfolded. It should also be clear that vertical determination or supervenience have nothing to do with causation: a substrate should not be thought of as literally generating or “giving rise to” the cause–effect structure unfolded from it (such terms, just like the term “emergence” [see below], may be convenient in usage, but at the risk of being misleading).
4 Causation: characterizing what causes what

Up to now, we have addressed the question “what exists?” We have aimed to account for our immediate, indubitable phenomenal existence in terms of the cause–effect powers of a substrate in a state—say, a set of neurons, some firing and some not. We have shown that it is possible to vertically unfold a Φ-structure that corresponds to a given experience.

We now turn to analyzing “what caused what?” This causal analysis can be formalized in a way parallel to the ontological analysis above and provides a self-consistent, quantitative account of many aspects of causation. Instead of considering the causal powers of a substrate in a state, we consider two successive occurrences—say, a set of neurons in an earlier firing pattern and a set of neurons in a subsequent firing pattern. And instead of vertically unfolding a Φ-structure, the analysis “horizontally” unrolls an Α-structure, which accounts for what caused what. In sum, while Φ-structures capture existence in terms of potential causes and effects, Α-structures capture causation in terms of actual causes and effects. Understanding both structures is essential in the account of free will.

4.1 Causal accounts and their Α-structure

As described above, to identify complexes and unfold Φ-structures, we employ the criterion for physical existence (0th postulate) plus the five postulates of IIT. Similarly, to identify causal complexes and “unroll” Α-structures, we employ the criterion of realization plus the five postulates to characterize the transition between two substrate states (occurrences). Briefly, realization means that to establish actual causation, there must have been a transition between two occurrences, and the first occurrence must imply an increased probability of the second one (effect direction), or vice versa (cause direction). Realization requires that we have a repertoire of counterfactuals, meaning alternative occurrences that could have happened but did not. Moreover, actual causation may look different from the two directions—not every cause corresponds to an effect, and not every effect corresponds to a cause. For example, the actual cause of a window being shattered may turn out to be a large rock, but this does not mean that a small rock hitting the window at the same moment did not have an effect.

The postulates of IIT appear in the analysis of actual causes and effects in the following form:

**Intrinsicality** means that actual causes and effects must be evaluated from the intrinsic perspective of the occurrence—relative to it (e.g., what cause makes the most difference to it).

**Information** means that cause and effect states are specific—corresponding to the states that actually occurred.

**Integration** means that a cause or effect must be irreducible; otherwise, there are two or more independent causes or effects rather than one. This irreducibility is measured by causal strength $a$, which is formally analogous to integrated information $\varphi$.

**Exclusion** means that every occurrence can only have one antecedent cause and only one subsequent effect—the one that is maximally irreducible.

**Composition** means that we should consider the actual cause or actual effect for every subset of a substrate, as well as the relations among causes and effects—how they overlap over units.

Causal analysis can be used to establish, first, an optimal causal account of a single transition, which is the one having maximally irreducible causal strength $\alpha^*$. For $\alpha = 0$, there is no cause, as is the case for complete indeterminism. The Α-structure and structured integrated causation Α of a causal account can then be assessed through composition by examining actual causes and effects of subsets of units in the account, as well as their relations. The key difference in computing causal strength $a$ and integrated information $\varphi$, and from there Α and structured integrated information $\Phi$, is that $a$ picks actual cause and effect states—those that actually occurred—whereas $\varphi$ picks potential cause and effect states—those that maximize intrinsic existence.

4.2 Causal processes

By forward- and back-tracking causal accounts for multiple adjacent transitions and evaluating their congruence (how an effect of a previous transition overlaps with the cause of the next transition), we can further characterize the horizontal unrolling of a causal process across many transitions over different substrates. A causal process typically has borders, a beginning, an end, and an internal structure, and it can occur at a macro- rather than at a micro-scale. The same way extrinsic entities hang together well, causal processes “flow together” well. Both causal accounts over one transition and causal processes over many transitions can be intrinsic or extrinsic—intrinsic if the causes and effects are inside intrinsic entities (say, a train of thoughts, one following the other), and extrinsic otherwise. A causal process can also be interpreted as a realization, over many transitions, of the causal potential of an entity in a state, given some background conditions.

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*Like integrated information, actual causation is based on probabilities and is sensitive to the tension between expansion and dilution (see footnote is). For example, a set of units may have an effect over a large number of units (the total effect), but only a few of these may turn out to be the actual effect.
4.3 Causation, prediction, and “horizontal” determination

There is a history of skepticism towards causation in both science and philosophy. It has often been assumed that the business of science is to predict accurately, not to postulate unobservable causes. All we can observe, in the end, are just conditional probabilities across occurrences. However, when dealing with complex systems, such as biological ones, prediction is problematic because we cannot rely on simple “laws.” Instead, to figure out how a complex system works, we need systematic interventions in addition to observations, ideally yielding an accurate “causal model.” For example, neuroscientists have long recognized that “correlation is not causation” and that, to understand the brain, we ultimately need an accurate model of neurons in a network. With such a model, we can predict the next state of individual units from the state of their inputs. If we do so for every unit, no extra work is needed to predict the state of the entire network. In other words, first-order prediction is all that is needed for high-order prediction.30

Even so, it is critical to understand that prediction is not the same as causation (table I). Consider again a network of neurons. Prediction can be understood as horizontal determination—the ability to unroll the future state of a system’s units based on knowledge of their past state and of the unit mechanisms. Instead, causation should be understood as the ability of a mechanism to take or make a difference, as demonstrated through observation and manipulation.

On this basis, it is easy to show that the two notions can be dissociated. For example, it is true that if something is caused according to a causal model, then it can be predicted, but the converse is not true: something can be predicted but not caused. Consider two identical, parallel chains of domino stones. Triggered by a common event, dominos in both chains start to topple. The fall of one domino in one chain reliably predicts the subsequent fall of the next dominos in both chains, yet it only causes the fall of the domino in its own chain (examples can also be drawn from neuroscience).30 Moreover, high-order prediction follows from 1st-order prediction: if the next state of neuron A is predicted, and similarly that of neuron B, then necessarily the next state of AB is also predicted. Not so for high-order causation: there may be many 1st-order causes (such as A and B) and no high-order causes (AB), or there may be a high-order cause (AB) in the absence of 1st-order ones (A and B). A similar dissociation can be shown for macro-causation vs. macro-prediction. Knowing the state of all relevant micro-units (say, molecules) over their micro-updates is sufficient to predict the state of macro-units (say, neurons) over macro-updates. However, causal analysis may show that actual causes and effects are maximal at the macro- rather than micro-level.

4.4 Causal closure and causal exclusion in extrinsic substrate views

In section 3.5, we discussed differences between IIT’s intrinsic powers view and standard extrinsic substrate views with respect to what exists. How do these ontologies differ with respect to what causes?

As we have seen, extrinsic substrate views assume that the microphysical substrate exists as such, endowed with physical properties such as mass and charge. Because it exists as such, it also causes as such.32 Emergent properties are also assumed to exist, albeit in a less fundamental manner, because they depend on the existence of the microphysical substrate. As we have also seen, their existence is justified by the role they play in explanation and by multiple realizability. The same logic can be applied to what might be called “emergent causation.” It seems that we cannot avoid resorting to high-level causes to understand our behavior. For example, “he caused a lot of hardship to a lot of people” can only be understood at the high level of agent causation. Moreover, high-level causation can be multiply realized. Could we not accept, then, that emergent causes are also causing, albeit in a less fundamental sense than microphysical causes?

Most think not. While extrinsic substrate views are not overly worried by ontological proliferation (emergent properties co-existing with their substrate), there is widespread worry about causal proliferation or “overdetermination.” The intuitive reason is based on the notion of causal closure of the physical world: microphysical causation is sufficient for determining everything that happens (horizontal determination)—in other words, no additional causal influences need to be invoked to determine what happens next.32 High-level properties and constructs are vertically determined by their microphysical substrate, both before and after causation takes place. Therefore, there is nothing high-level properties and constructs can do causally above and beyond what has already been caused at the microphysical level. In short, a principle of causal exclusion is applied according to which microphysical causation excludes higher-level causation.32

4.5 Intrinsic and extrinsic causes: only what truly exists can truly cause

IIT’s intrinsic powers ontology, augmented by its causal analysis, leads to a fundamentally different view: only what truly exists can truly cause. This means that only intrinsic entities can truly cause, and their microphysical substrates cannot cause anything because they do not truly exist. Accordingly, a causal

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30 This holds inasmuch as causation is acknowledged and distinguished from prediction.
32 This holds unless one subscribes to interactionist dualism, according to which mind can have effects on matter, or to strong emergence, according to which new physical forces or laws may come into being at higher levels of organization.
account or process originating inside an intrinsic entity is a true cause—an **intrinsic** cause—because it is produced by something that truly exists. Similarly, a causal account or process ending inside an intrinsic entity—an intrinsic effect—is a true effect because it is borne by something that truly exists (table I).

To exemplify, consider two occurrences in which my hand is raised. In one case, my hand is raised because I have decided to do so voluntarily—say, to ask a question. Causal-process analysis would establish that the **distal** cause—where the causal process begins—resides in a large intrinsic entity, the large \( \Phi \)-structure corresponding to my experience of deciding. The causal process originating within my posterior cortex activated motoneurons in my motor cortex, neurons in the spinal cord, and eventually muscles that raised the arm. The distal cause is therefore intrinsic because it occurs within an intrinsic entity.\(^{xxii} \) Because an intrinsic entity exists for itself, when it produces certain external effects, it can be considered an **autonomous agent**, and when it is sensitive to certain external causes, it can be considered an **autonomous perceiver**.

In a second case, my hand is raised involuntarily because of some burst of activity in the motoneurons in my spinal cord while I am deeply asleep and unconscious. Causal-process analysis would establish that the distal cause is spread out among small entities of neuronal “dust” (no large complex with a large \( \Phi \)-structure but many small ones): a causal process originated in a set of neurons in my spinal cord due to some stochastic firing, and eventually triggered a coordinated raising of my hand. In this case, the distal cause remains extrinsic because it cannot be attributed to a single intrinsic entity: nothing exists that would serve as an agent or perceiver.

At first, the intrinsic powers view may seem counterintuitive. For instance, it implies that bodies and rocks do not truly exist since they only exist as extrinsic entities, relative to a conscious observer and manipulator, but not as intrinsic entities—for themselves, in an absolute sense. The situation is similar for extrinsic causes. Take the case of a rock rolling down a hill and crashing into an empty car. Causal analysis would show that the rock was the cause of the car being crashed, and the car being crashed was its effect. However, both the cause and the effect would be extrinsic, because neither the rock nor the car exist as intrinsic entities (but only as aggregates of much smaller intrinsic entities that hang together tightly).

In a fundamental sense, then, because there is ‘nothing it is like’ to be a rock or a car, the rock cannot be a true cause and the crashed car cannot suffer a true effect, for *only what truly exists can truly cause.*\(^{xxii} \) This conclusion does not mean that an extrinsic causal analysis yielding the rock as an extrinsic cause and the crashed car as an extrinsic effect would be meaningless, or that one should cease speaking about the rock as causing the crash. Just as relative maxima of \( \Phi \) identify things that “hang together well,” such as rocks and cars, bodies, and spinal cords, maxima of \( \alpha \) can identify causal accounts and processes that connect extrinsic entities and “flow together well.”

The requirements for high \( \mathcal{A} \) are very similar to those for high \( \Phi \) because they are similarly based on the postulates of IIT. Therefore, a distal cause that begins or an effect that ends in a \( \Phi \)-structure of high \( \Phi \) will typically have high \( \mathcal{A} \). In other words, the more an entity is conscious, the more strongly it can cause, and the more strongly it can bear an effect. Thus, raising my hand to ask a question not only has an intrinsic cause—my conscious decision to ask—but it likely have a strong cause. Instead, a near-random coincidence of firing in the spinal cord, which just so happens to raise my hand when I am asleep, will have a comparatively weak cause, in line with the spinal cord not being conscious—a mere aggregate. In general, we should expect a proportionality between the \( \Phi \) value of a \( \Phi \)-structure, and hence of \( \Phi \)-folds within it, and the \( \mathcal{A} \) value of a causal account. As we will now argue, intrinsic causes and effects underlie free will and the ability to choose.

| Table I: Some key contrasts in IIT’s ontology |
|---------------------------------------------|
| constitution ≠ existence                   |
| intrinsic entity                           |
| (an absolute maximum of \( \Phi \))         |
| extrinsic entity                           |
| (a relative maximum of \( \Phi \))          |
| intrinsic causation                        |
| (begins or ends in an intrinsic entity)     |
| extrinsic causation                        |
| (does not begin or end in an intrinsic entity) |

| Table II: Requirements for free will |

**Consciousness**
- **Alternatives:** I must be able to envision multiple courses of action. (freedom of imagination)
- **Reasons:** I must be able to choose based on reasons. (freedom of evaluation)
- **Decision:** I must be able to decide and intend an action. (freedom of decision or will)
- **Control:** I must be able to cause, control, and execute an action. (freedom of execution)

\(^{xxii} \) More precisely, the distal cause must be specified by a subset of the same macro-units that compose a \( \Phi \)-structure, over the same macro-state.

\(^{xxiii} \) Instead, it would be a case of “dust” causing “dust” (each mini–dust entity affecting some mini–dust entity).
5 Requirements for free will

The main thesis of this essay is that we do have free will in a fundamental sense—true free will—and not just “free will” as a convenient manner of explaining our actions. Before substantiating this claim in the IIT framework, let us return to the simple scenario introduced at the beginning and examine the essential requirements in more detail. It is generally recognized that free will requires consciousness. But consciousness is not enough (table II). In other words, there cannot be free will without consciousness, but there can certainly be consciousness without free will. A proper free will scenario requires that I can envision alternative courses of action (freedom of imagination); that I can weigh reasons to choose among alternatives (freedom of evaluation); that I can decide and intend an action (freedom of decision or will); and that I can cause, control, and execute an action to carry through my decision (freedom of execution).

Freedom of imagination. Say I am driving on a long stretch of a deserted highway as if on autopilot, immersed in the music from the radio. While I am conscious and in control of the car, I do not envision alternative courses of action, so freedom does not come into play (until, of course, I wonder whether I should turn left to go home or right to go for a drink). The same applies if I were to do what I am told without ever considering that I might do otherwise. Note that it would not matter at all whether, due to some accumulation of indeterminism, two possible trajectories were open to me. What matters is only that I am conscious of a fork, so to speak, in my mental road—that I realize I have a choice.

Freedom of evaluation. Say I do see alternatives but choose automatically among them, almost reflex-like, because I have been thoroughly indoctrinated about what is the right choice. If I never considered the reasons why I should choose this rather than that, I am not free. I may consider my reasons quickly, or instead go through a long, agonizing process, but as long as I have considered my reasons, I have freedom of evaluation.xxvii Usually, when a choice is difficult, I am also acutely aware that the choice is ultimately up to me and up to me only—that I am free to choose. In fact, awareness of the very concept of freedom and free will adds to the poignancy of the choice I must make.

Freedom of decision or will. Say I am asked to vote for or against a resolution that is unpopular but ethically well grounded. Normally, I would consider my alternatives, go through my reasons, and decide to vote accordingly. In this case, I would have decided as I intended and exercised my free will. But now imagine that, just when I am about to decide, somebody intervenes and, by targeting an intense magnetic field to neurons involved in decision-making in my brain, causes them to fire and “decide.” In such case, the decision cannot be considered an expression of my own free will. Similarly, even though I may have pondered alternatives and gone through my reasons, if in the end I succumb to a sudden fit of rage, my decision was not freely willed.xxv Of course, if I am unable to decide because I am paralyzed by doubt, I also lack will.

Freedom of execution. Say I see alternatives (should I drink alcohol or not?), go through my reasons (for the sake of my health, I should not), and decide to quit (I will not drink). However, if my resolve is thwarted by an overwhelming push to transgress, I may fail to carry out my decision and cannot control my action. In that case, I lack freedom of execution. Note that this kind of “push” can be considered extrinsic, even though it may originate within my brain but outside the main complex, because I am not able to control it through my will. The same is true, of course, if I cannot carry out my decision because I am prevented by somebody or something extrinsic to me.

Footnotes:

xxv My choice can still be considered free even if I do not reconsider my reasons in any depth because I have done so in the past and molded my own character, beliefs, and values through self-changing actions (see below). However, I must be willing and able, in principle, to reconsider them in view of new circumstances.

xxv We will not consider simple urges, say, extreme hunger or thirst, as adequately representative of a true free will scenario, which involves the conscious consideration of alternatives and reasons. While an urge followed by a decision captures the “will” portion of free will as well as freedom of execution, it does not capture freedom of imagination and evaluation.
6 True free will: the intrinsic powers view

We will now consider how we can account for the free will scenario introduced at the beginning of this essay in view of IIT’s ontological foundations and its characterization of actual causation.

6.1 I have alternatives—not my neurons

As summarized earlier, by IIT, all contents of experience correspond to sub-structures within a cause–effect structure—to Φ-folds within a Φ-structure. This applies not only to the experience of space, time, and objects, but also to conscious thoughts and feelings of any kind. For example, the conscious content of a thought might correspond to the higher (more abstract) levels of a conceptual hierarchy, bound by relations to sub-structures corresponding to the sound of certain words. Conscious alternatives, too, are Φ-folds within the Φ-structure corresponding to an experience. Right now, I may conceive of two alternative courses of action as a silently verbalized thought. Such a thought would correspond to a large Φ-fold that likely includes several conceptual hierarchies, extensions, flows, and high-level concepts such as the self. Different Φ-folds may come into being when I go back and forth between possible courses of actions and their consequences, recall episodes from memory, and so on.

At some point, I will end up with a thought that binds two alternative possibilities into a choice that is available to me: I have arrived at a fork in my mind (fig. 6). That conscious choice exists phenomenally, and it must be accounted for, in physical terms, by a Φ-fold within the Φ-structure corresponding to my experience. In fact, as argued in section 3.5, that Φ-structure unfolded from my main complex, and the Φ-fold within it, is all that exists in an absolute sense—that is, for itself. The substrate and the neurons constituting it do not exist as such, but only relative to an observer—as an operational basis for unfolding causal powers. And, as argued in section 3.5, the neurons of the main complex do not exist unfolded either (as minuscule intrinsic entities). This is because, over a given substrate, what exists is only the entity that exists the most, which is the much larger intrinsic entity corresponding to my experience. So it is I who exist—not my neurons. And it is my thought of alternative actions—my conscious choice—that exists here and now as a Φ-fold in the Φ-structure of my experience—a fork in my mind (a “Y”). What exists is not a set of alternative trajectories that my brain may follow—a fork in the road” (a “<”), say, due to indeterminism (see sec. 8).

![Diagram](image)

**Figure 7. The intrinsic powers view of IIT: Only what truly exists can truly cause.** My experience of alternatives, reasons, a decision, and the feeling of control correspond to Φ-structures unfolded from my substrate. At any one moment (say, the decision moment), one such Φ-structure (the one in color) is what truly exists. And as such, they are what can truly cause. A causal account of the decision is depicted by the red cause lines and the green effect lines, representing the supported Φ-structures. On the cause side, one sub-structure in the reasons Φ-structure is the actual cause (with structured integrated causation Φ > 0) of a sub-structure in the decision Φ-structure. On the effect side, the actual effect (with Φ > 0) is the movement enacted by my motor system (indicated by the muscle, bottom right), which I control, as well as the feeling that “I am doing it.”
6.2 I have reasons, decisions, and control—not my neurons

The same logic applies to subsequent moments of the free will scenario (fig. 7). A reason—a thought about what might justify a choice—exists as a Φ-fold within a current Φ-structure. Reasons likely correspond to very complex Φ-folds, and so do conscious beliefs, values, and the feeling that my own self is involved in a decision. According to IIT, all this content comes into existence when it is thought consciously, and it vanishes the moment it ceases to contribute to my current experience. Similarly, the feeling of making and then having made a decision, the feeling of my intention to carry it out, and finally the feeling of control—whenever they come into being as contents of my current experience—exist as large Φ-folds within the corresponding Φ-structure. And again, whenever I experience such contents, it is I who exist and I who have reasons, decisions, intentions, and control—not my neurons, which do not also exist.xxvi

We can now consider what caused my decision and my subsequent action. Recall that the question “what caused what?” is addressed by “unrolling” an A-structure, which causally links two occurrences (in this case, two consecutive neural firing patterns in my brain).

Let us focus on the conscious moment at which I decide that “I will do this” (fig. 7). The experience corresponds to a Φ-structure unfolded, say, from a set of neurons in posterior regions of my cerebral cortex, some firing and some not (the main complex). The decision corresponds to a Φ-fold within the Φ-structure specified by a subset of those neurons. The previous conscious moment, say, the experience of a decisive reason why I should choose one alternative and not the other, corresponded to a different Φ-structure, unfolded from a different firing pattern over some other subset of main complex neurons.

In principle, the A-structure that accounts for what caused my decision could now be calculated (fig. 7). We would have to assess the actual causes (and associated relations) of the actual state of the main complex neurons specifying the Φ-fold corresponding to my current decision. As illustrated schematically in the figure, these actual causes and relations are likely to involve many of the neurons that, a moment before, had specified the Φ-fold corresponding to my experience of a decisive reason. Because Φ-folds within Φ-structures of high Φ are composed of many distinctions and relations, the causal account linking my current decision Φ-fold to my previous reason Φ-fold will likely support a large A-structure composed of many actual causes and their relations.xxvii

The causal account on the effect side of my decision would behave similarly. The neurons specifying my decision Φ-fold will have strong actual effects over the next state of many neurons. Some of these will then trigger further effects downstream, eventually leading to the activation of motoneurons and muscles, ending in an action such as raising my hand. Again, the A-structure on the effect side will typically be large because, by originating within a Φ-structure of high Φ, it will be composed of many actual effects and their relations.

In this way, one could unroll “what actually caused what” in physical terms: my decision Φ-fold was caused primarily by a decisive reason Φ-fold that allowed me to choose among several alternative Φ-folds; in turn, my decision Φ-fold caused my subsequent action. And because the causal account of my decision ends within an intrinsic entity on the cause side (what caused it) and begins from an intrinsic entity on the effect side (what it caused), my decision truly exists, has a true cause, and produces a true effect. Recall the conclusion from section 3.5 on ontology: I truly exist—not my neurons. And recall the conclusion from section 4.5 on actual causation: only what truly exists can truly cause. So I exist and cause—not my neurons.

6.3 A computer simulating my brain (or my functions) would neither truly exist nor truly cause

This case for true free will may be further illuminated through a contrast with digital computers. A digital computer may be programmed to be functionally equivalent to a system it is simulating, yet specify Φ-structures that are radically different.xxviii For example, the behavior of a small system of three logic gates (named PQR) can be simulated by a simple universal computer constituted of sixty-six logic gates (named PQR). PQR’ is functionally equivalent to PQR: in terms of what it does, PQR’ indeed does the same as the system PQR it is simulating. However, PQR is a single complex with Φ > 0, unfolding into a Φ-structure composed of numerous distinctions and relations. By contrast, the much larger substrate PQR’, the computer taken as a whole, has Φ = 0, being fully reducible. Subsets within it, such as memory registers and the clock, have Φ > 0. However, the trivial Φ-structures unfolded from these subsets have nothing to do with the Φ-structure of the system PQR that is being simulated. In fact, those Φ-structures would be the same no matter which system were simulated by PQR’. Thus, the system PQR and the computer PQR’ simulating it are functionally equivalent but not ontologically equivalent: PQR is a

xxvi The feeling of agency—that I was the one responsible for executing an action—is also typically associated with free will, though under certain circumstances one may incur illusions of agency. Here we focus on the feeling of control that accompanies the deliberate carrying out of a decision.

xxvii The strength of actual causes (a) and of intrinsic causes (φ) tend to be correlated. In a relatively isolated system (say, my brain when dreaming or thinking), the actual cause of a mechanism in a state will tend to line up with its intrinsic cause.
single intrinsic entity (albeit small), while PQR’ is just an aggregate of “dust.”

In short, the computer as a whole does not truly exist (for itself) as it is not an intrinsic entity. It only exists for us as a useful substrate to perform certain functions. But then, if the computer does not truly exist, it cannot truly cause. In fact, causal analysis would reveal many separate causal accounts linking, say, individual transistors constituting a memory register, fig. S1).

7 The impossibility of true free will: the extrinsic substrate+ view

Let us now contrast again IIT’s intrinsic powers view with the extrinsic substrate+ view. The latter comes naturally to most people, whether as naïve realists or as sophisticated scientific realists. In this view, physical substrates exist as such: my body certainly exists as a physical substrate, and so do my head, my brain, my cortex, its posterior regions, or any particular cortical area. The units we can observe and manipulate with the tools of science also exist as such: neurons certainly exist, and so do ion channels and even atoms, at any spatial and temporal scale we may be interested in. Furthermore, the

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**Figure 8. The extrinsic substrate+ view: no room for true free will.** My experience of alternatives, reasons, a decision, and the feeling of control are functional states and constructs ontologically determined by the physical substrate of my brain (vertical arrows indicating “emergence”). Such constructs may be necessary for causal explanations across functional states (dotted horizontal arrows) and may be multiply realizable. Yet the true cause of each subsequent state is ultimately determined at the microphysical level (solid horizontal arrows).

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xxviii These conclusions do not depend on the size or complexity of the system to be simulated or on the size of the computer simulating it. (We are leaving aside questions related to fully neuromorphic computers and of quantum computers.)

xxix The substrate+ view of seemingly “good enough free will” may well be compatible with determinism, but that is beside the point here.
emergent properties and constructs (“functional states” in the figure), which might correspond to, say, imagining alternative courses of action. In this view, the next state of the neurons constituting my physical substrate is causally micro-determined by their previous state, at least over the few seconds of the free will scenario. As illustrated in fig. 8, my neurons will switch from state to state in a way that is causally determined, in microphysical terms, by their inputs (their previous state) and their mechanisms. Inevitably, the same way my experience of imagining alternatives is ontologically determined by a neural state, my experience of a decisive reason favoring the first alternative is vertically determined by a neural state, as is my experience of deciding for one alternative.

The extrinsic substrate+ view emphasizes that the microphysical level is sufficient to predict what I do next but that it may not be able to provide a causal explanation of my behavior—why I did this rather than that, or what I meant when I said that my choice was voluntary. For that, we need to resort to high-level constructs, such as alternatives, reasons, and decisions. Moreover, the high-level constructs may be “multiply realizable” and thus not reducible to the neural substrate—another person may go through the same

alternatives, reasons, and decisions, but these may be microphysically determined by different neural states.xxx

However, despite attempts to reconcile the microphysical with high-level constructs, the extrinsic substrate+ view remains wedded to the assumption that the microphysical substrate exists as such and that it is ontologically fundamental or primary. High-level functions and constructs, as well as phenomenal states, are ontologically derived or secondary because they are determined by states of the microphysical substrate by which they are ontologically determined. Causation is microphysical. A substrate goes through a series of states, in which the present state of each microunit is causally determined by inputs from its past state. Reasons and decisions do not truly cause but may be necessary for causal explanations and because of multiple realizability.

xxx Similar considerations apply not just to humans but also to complex artifacts endowed with autonomy and goal-directed behaviors. It does not make sense to try to account for the decisions made by an intelligent, autonomous robot purely based on the interactions among its transistors or atoms. Instead, we must resort to the high-level program that is guiding its actions. Moreover, the same behaviors can be implemented on different hardware platforms.

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**Table III: Intrinsic powers ontology**

| Existence |
| --- |
| • Only intrinsic entities truly exist as such. |
| • A substrate is “physical” in an operational sense. It comes down to conditional probabilities among micro-units that can be observed and manipulated, yielding a transition probability matrix (TPM). |
| • As such, it permits the operational determination of the Φ-structure of an intrinsic entity by “unfolding” its cause-effect power (physical existence) based on the essential properties of experience (phenomenal existence). |
| • Alternatives, reasons, and decisions exist as sub-structures (Φ-folds) within an intrinsic entity. |

| Causation |
| --- |
| • Alternatives, reasons, and decisions truly exist, but the micro-substrate from which they can be operationally unfolded does not exist as such. |
| • Decisions truly cause, because only what truly exists (intrinsically) can truly cause. Intrinsic causation is characterized by an A-structure that links sub-structures within a preceding Φ-structure with sub-structures within a subsequent Φ-structure. |
| • Decisions exclude micro-causes. |

**Table IV: Extrinsic substrate+ ontologies**

| Existence |
| --- |
| • Physical substrates exist as such. |
| • A substrate is “physical” in an ontological sense. It is constituted of micro-units endowed with intrinsic physical properties (mass, charge, spin) and following the “laws” of physics. |
| • As such, it ontologically determines or “gives rise” to emergent functions, such as decision-making, or emergent feelings, such as that of agency. |
| • Emergent functions or feelings are considered “real” insofar as they are necessary for explanation and because of their multiple realizability. |

| Causation |
| --- |
| • Alternatives, reasons, and decisions are “carried along for the ride” by states of the microphysical substrate by which they are ontologically determined. |
| • Causation is microphysical. A substrate goes through a series of states, in which the present state of each microunit is causally determined by inputs from its past state. |
| • Reasons and decisions do not truly cause but may be necessary for causal explanations and because of multiple realizability. |
Therefore an illusion: free will may be treated as “real” in a practical and social sense, but it cannot possibly be “true” in a fundamental sense. In the end, I always do what my neurons do—I am just “carried along for the ride.”

By assuming the fundamental existence of microphysical substrates as such, the extrinsic substrate view inevitably leads to a cognitive dissonance. On one hand, I believe that my brain exists as such, and that it is made of neurons. I also believe that my feelings and thoughts emerge upon the brain’s microphysical substrate. Finally, I know that neurons do what they do based on their inputs. Therefore, whatever my feelings and thoughts might be, I cannot help doing exactly what my neurons do. And because neurons don’t have a choice, neither can I. On the other hand, I vividly experience alternative possibilities and struggle to make the right choice, and I cannot help feeling that I am the one deciding what to do. So it must be that my choice, my freedom, and my will, are ultimately illusory.

This dissonance is resolved only by abandoning the extrinsic substrate view and recognizing the intrinsic powers view as the proper ontological starting point (Tables III and IV). To understand consciousness and free will, I must acknowledge that what truly exists is my experience and conclude that it can be accounted for, in physical terms, to the Φ-structure unfolded from a complex. I must realize that the only alternatives, reasons, and decisions that truly exist are those that exist in my experience, corresponding to sub-structures within a Φ-structure. It is thus wrong to think of what I am conscious of as being ontologically determined by my substrate, as if the substrate existed as such—as an aggregate of atoms that “gives rise” to my experience. Instead, the substrate must be considered as an operational basis from which one can operationally determine (unroll or predict) the properties of experience.

In short, I must realize that if my experience exists, then my neurons do not also exist, neither as a substrate as such nor as little entities of their own.

Similarly, I must realize that my decision is truly caused by my reasons and that it truly causes my action. Thus, it is wrong to think of my decision as being causally determined by the previous state of my substrate, as if that substrate existed physically as such and caused as such. Instead, the substrate must be considered as an operational basis from which one can determine (unroll or predict) the next state. But my decision is not caused by the substrate, because only what truly exists can truly cause, and what truly exists is the Φ-structure unfolded from a complex, not a substrate as such.

### 7.2 No choices and decisions, problems and solutions, questions and answers?

The intrinsic powers view of existence applies not only to alternatives, reasons, and decisions, but to everything that exists in the mind and thus truly exists. For example, facing a choice and making a decision is similar in nature to many other high-level, abstract experiences, such as having a problem and finding a solution, or having a question and finding an answer. Compared to the intense debates about the possibility of genuine alternatives and genuine decisions, there has been little concern about whether there may be genuine problems and solutions, genuine questions and answers. The reason, most likely, is that the debate on free will has focused on determinism rather than on existence, and determinism may seem more problematic for achieving freedom than for finding answers or solutions.

But if we adopt the extrinsic substrate view, just as we cannot truly have a choice and decide how to act, we cannot truly have a problem and solve it, or truly have a question and answer it. Like choices, problems and questions may be considered emergent constructs that are necessary for explaining our behavior and that cannot be reduced to a physical substrate owing to multiple realizability. But like decisions, solutions and answers must be determined by the physical micro-substrate, which is assumed to exist as such and which inexorably updates its state, each one causing the next. Once again, we are just carried along for the ride, thinking we have solved the problem or answered the question.

In the intrinsic powers view, by contrast, there are true problems and true solutions, true questions and true answers. Like alternatives and decisions, they exist intrinsically as sub-structures within the Φ-structure that corresponds to our current experience. In fact, problems and solutions, questions and answers exist only as contents of experience within individual subjects. They do not emerge from a neural substrate that exists in its own right, nor do they live in a separate realm of ideas. I have problems—not my neurons.

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***xxi*** It is often pointed out that several empirical results confirm the illusory nature of free will. In Wegner-style experiments, which manipulate delays and what the subject sees, a subject can be convinced that they were responsible for moving their hand “of their own free will” when it was actually the experimenter who did so. Similar misattribution of agency can also occur during seances. These illusions demonstrate that, under special conditions, our experience of agency is fallible but not that, under typical conditions of deliberation and action, our free will is an illusion.

***xxii*** One way around this conclusion is to appeal to an immaterial soul that can suspend the workings of the brain, decide autonomously, and tell the neurons what to do. But barring such an interactionist-dualist leap of faith, there seems to be no way out.

***xxiii*** In fact, in the extrinsic view, one might argue that genuine free will is simply an incoherent notion: determinism or not, we should just “get over it.” This is because our actions are either fully determined by our neurons, in which case we have no freedom, or they are not, in which case they are due to chance, not to our will.
8 Freedom, indeterminism, and predictability

IIT’s argument for true free will hinges on the proper understanding of experience as true existence and on the intrinsic powers view: what truly exists, in physical terms, are intrinsic entities, and only what truly exists can cause. On the other hand, much of the debate about free will has revolved not around existence but around the role of indeterminism. What does IIT have to say about indeterminism and its significance for free will?

We will briefly address three points. First, a degree of fundamental indeterminism is mandated by IIT’s requirements for intrinsic existence. Second, this fundamental indeterminism is not the reason we have true free will; in the timeframe of a few seconds, our actions are likely highly determined and thus predictable. However, since existence is not constitution and causation is not prediction, true free will is not only compatible with a high degree of determinism but requires it. Third, fundamental indeterminism matters in the long term. If we have true free will, and if the future is not preordained, we are responsible not only for our present actions but, in a very real sense, for what they bring about in the future: our freely willed actions are both self-changing and world-changing.

8.1 IIT and fundamental indeterminism

IIT assumes an explanatory model based on cause–effect power “all the way down.” To be self-consistent, this model requires that the smallest units that can take and make a difference—the atomic units of cause–effect power—should satisfy the requirements for intrinsic existence.19 This means that, in principle, each unit must have a difference available, in the sense of an intrinsic repertoire of states, and must be able to take and make a difference from and to itself, regardless of the input from other units (the “background conditions”). This leads to a tension between indeterminism and determinism, where indeterminism provides the difference, and determinism takes and makes the difference. Thus, a degree of micro-indeterminism is required to ensure that intrinsic cause–effect power is available all the way down.

8.2 Free will and predictability

In a typical free will scenario, say, one taking place over a few seconds, micro-indeterminism is unlikely to influence my decisions (and if we were to discover that quantum indeterminism may play a role in the firing of neurons, that kind of chance will not buy us any freedom, only a minor degree of unpredictability). As a consequence, decisions and actions should be largely predictable. In fact, they may often be partially and coarsely predictable at a high, psychological level. For example, people who know me well may be able to correctly predict how I will choose in specific circumstances simply because they have a good understanding of my values and beliefs and how they might determine my actions.

Or my decisions and actions may be fully and precisely predictable based on a low-level, detailed model of my brain. The question is whether predictability is incompatible with free will. For example, consider a scenario in which I am asked to choose to which charities I wish to donate.34 One day, a computer simulating the interactions among my neurons with utmost precision should be able to achieve near-perfect prediction over the few seconds of my deliberations, as long as they take place in a controlled environment. Moreover, a very fast computer should be able to systematically predict my choices before I make them.35 This would certainly evoke an eerie feeling of alienation—of being a mere “puppet.” If every detail of my behavior is fully predictable in advance, how can I possibly be free?

As before, determination and the ensuing predictability seem to leave no way out for true free will. And, as before, the problem is that the notions of determination and predictability are based on the extrinsic substrate view. In that view, my brain exists as such: it is a complicated physical substrate—a biological machine—that follows a single, predetermined trajectory. It has no alternatives or choice and, at least in the short run, it cannot help but “go through the motions.” And while it may well be that my functional states, as well as my feeling of having alternatives and making decisions, cannot be reduced to their physical substrate in the brain, they are ontologically determined by it and are the result of microphysical causation. Inexorably, regardless of my protestations, I am just carried along for the ride.

But if we start from phenomenology and take the intrinsic powers view, the perspective on what actually exists changes radically. My freedom depends on the true existence of multiple alternatives in my mind, here and now, not on the possibility of multiple trajectories unrolling over time. It is not chance but choice that makes us free—not a fork in the road ahead (<) but a fork in the mind here and now (Y). Trajectories themselves are just useful predictive devices for conscious observers (equipped with powerful computers): they do not truly exist as such, but only in the mind of the observer who can interpret them.36

In summary, high-level predictability is not a problem for free will: if my alternatives are evaluated based on my reasons, my reasons cause my decisions, and my decisions cause my actions, no wonder prediction is possible. If I have strong reasons for choosing the way I did, then under the same circumstances, I should freely make the same choice, again and again. Nor is low-level, microphysical predictability a

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xviii The availability of alternative extrinsic trajectories due to indeterminism is not necessary for freedom, but neither is it sufficient. If I am not conceiving alternatives in my mind, it is irrelevant that indeterminism in my brain might leave open multiple trajectories for my future actions. Whatever action occurs would be due to chance and not to will.
problem. A detailed, low-level model of the main complex is one that offers a good operational account of what truly exists (by unfolding $\Phi$-structures) and of what truly causes (by computing $\mathcal{A}$-structures originating in $\Phi$-structures). If the model of what exists and causes is good, it will also predict well what will exist next (my decision will come into being, caused by my reasons, and it will cause my action). But if the model is good, it will also offer a shortcut to predict what happens next without even bothering to unfold what truly exists and causes: we simply need to unroll the successive states of every unit based on its inputs and mechanism. In short, true free will is fully compatible with full predictability.

From this perspective, it is justified to have a feeling of alienation if confronted with a computer simulation predicting my decision: the simulated neurons are indeed “not me”—they don’t truly exist or truly cause, even though they can be a convenient operational shortcut for unfolding what exists and causes and predict what happens next.

As such, with full rationality comes full responsibility.

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**Figure 9.** Historical determination and personal responsibility: the extrinsic substrate view. Governed by the “laws of physics,” microphysical substrates give rise to basic life forms, which eventually evolve into animals, such as myself, with sophisticated emergent functions, such as decision-making, language, and rationality. However, these functions emerge upon the microphysical substrate and are “carried along for the ride.” Hence, nothing is truly my responsibility but is determined by previous occurrences and chance at the microphysical level.

**Figure 10.** Historical determination and personal responsibility: the intrinsic powers view of IIT. As the universe evolves, what first exists are merely small aggregates of ontological “dust”—intrinsic entities characterized by negligibly small $\Phi$-structures. Organisms eventually evolve with neural substrates, portions of which unfold into $\Phi$-structures of high $\Phi$. True free will becomes possible in an intrinsic entity, such as myself, with a $\Phi$-structure complex enough to conceive of alternatives—a “fork in the mind”—and to reason about them. My capacity for true free will grows the more I can exercise self-changing actions—those that modify my own substrate—along with world-changing actions—those that modify my surroundings. These capacities enable me to develop rationality and render me truly responsible for my decisions. As such, with full rationality comes full responsibility.

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xxxv If the model is correct, the prediction will be correct. But that does not mean that the model exists or causes. Imagine the model were simulating the cerebellum or another computer; the prediction would be just as good, but neither the model nor what it models would exist or cause. More generally, prediction is blind to existence, borders, grain, and structure.\footnote{xxxv}
8.3 Historical determination and personal responsibility

We have seen that short-term determinism, whether at the level of my values or my neurons, is compatible with true free will and not just with free will of convenience. xxxvi Nevertheless, modern physics assumes that a degree of fundamental micro-indeterminism at the quantum level is part of the fabric of nature. As described above, the same assumption is made by IIT purely as a requirement for intrinsic existence. With respect to free will, the main consequence is not that fundamental indeterminism makes us free, but that it makes the unrolling of the universe unpredictable in principle, hence not preordained, at least in the long term. Therefore, given indeterminism, true free will, and considering the further ability of freely willed actions to modify their own substrate, we are truly responsible not just for our actions here and now, but also for how they will change ourselves and our environment in the future.

To see why, the contrast of views is, again, helpful. In the extrinsic substrate* view, the universe unrolls according to the “laws of physics,” and under certain conditions, it may “give rise” to physical substrates of increasing complexity, such as those that can support life, multicellular organisms, and biological intelligence (fig. 9). Eventually, highly evolved animals such as ourselves become endowed with sophisticated emergent functions, including rational thought and language, which allow us to build societies and cultures. The evolution of the universe, as well as the precise course of evolutionary and cultural events on earth, are fundamentally unpredictable due to the inherent indeterminism of the microphysical world. As we have seen, however, indeterminism does not buy us freedom, just some measure of unpredictability. Everything that happens is either determined by the previous state of the universe, in which case we can say that it is caused at the microphysical level, or it is not determined, in which case we can say that it occurs by chance. In all cases, my emergent functional (and phenomenal) states can only “go along for the ride,” without exerting any influence on what happens next.

In such a scenario, nothing is truly my responsibility; everything is either determined by previous occurrences or just happens by chance. In the extrinsic substrate* view, then, I can only be held responsible in a pragmatic, socially motivated sense. Accordingly, an enlightened society may decide to employ preventive dissuasion rather than punishment, but in the end, even that societal decision is not truly free.xxxvii

The intrinsic powers view is radically different (fig. 10). At some point in the history of the earth, organisms evolved that harbored neural substrates unfolding into \( \Phi \)-structures of high \( \Phi \).xxviii These organisms have full-fledged experiences: there is much “it is like to be” them because they exist as large intrinsic entities. As we have also seen, being highly conscious is not sufficient for free will. For that, organisms must evolve who are able to envision alternatives; assess them against reasons; decide on the basis of those reasons; and intend, cause, and control actions. Conscious notions of the self, of values, and of beliefs are also typically needed, and so is understanding: the broader the conscious context of my choice, the more it is caused by me.

Once free will comes into being on the face of the earth, it transforms those who harbor it and the world that surrounds them, molding both self and environment towards values and purposes. Self-changing actionsxxxix are those, freely willed by me, that cause a long-lasting change in the mechanisms and connectivity of my substrate—that is, ultimately, in its TPM.xxx For example, suppose I decide to devote myself to the study of medicine to improve the human condition. Over time, what I study will change the connections among neurons in my substrate and thereby change who I am—my reasons, values, beliefs, and even the strength of my resolve (or willpower). Or I may decide to devote myself to the preservation of the environment, changing not just myself but also what surrounds me. My actions then become world-changing actions.

Because I can perform self-changing and world-actions out of my own free will, I acquire true responsibility (as do any other beings with true free will, and nothing else). If I have free will, my freely willed actions cause what will happen in the long run, what I will become, and how I will affect the world, molding myself and environment according to my purpose, not at the whim of chance. Furthermore, my personal responsibility can only grow with increased consciousness and understanding—that is, with increased freedom of my will. Finally, if I cultivate the ability to assess and criticize reasons, values, and beliefs in a rational manner, I will become

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xxxvi This refers to the pragmatic variety of free will used by the legal system and throughout society, which holds that adults are responsible for their actions except under conditions of duress, insanity, and so on.

xxxvii This sentiment was expressed well by Omar Khayyam:

“And that inverted Bowl we call the Sky,
Whereunder crawling coop’t we live and die,
Lift not thy hand to It for help – for It
Rolls impotently on as Thou or I.”

xxviii Studies using simulated organisms with a simple brain, called animats, illustrate how selective pressure may favor the evolution of substrates having high \( \Phi \).36

xxxix The term is similar to “self-forming actions.”14 However, in IIT self-changing actions are free not through indeterminism, but because they are caused by an intrinsic entity who conceives alternatives and reasons, makes decisions, and controls actions.

xxx In IIT, changes in the TPM itself are justified by the principle of becoming, which says that powers become what powers do.19 Briefly, powers are nothing but conditional probabilities reflected by the TPM, and as such, they too update when unit states update. The plasticity of powers ultimately provides the sufficient reason for the powers to have become what they have become, rather than being what they are arbitrarily (for no reason). The precise way in which powers are updated—how actions beget powers (the plasticity function, coupled with the activity function—how powers beget actions)—must be consistent with the principles and assumptions of IIT and is discussed elsewhere.19
fully free and thereby fully responsible. This is because my choices will no longer be constrained by my own subjective beliefs alone, but they will be evaluated under the objective (and inter-subjective) light of reason. With freedom, indeed, comes responsibility, and with that the opportunity to shape an open-ended future according to our will, guided by rationality.

These conclusions derived from the intrinsic powers ontology and its account of causation happen to align with both common sense and many spiritual, religious, and wisdom traditions: we can be the true authors of our deliberate actions, and we bear responsibility for their consequences. As a popular saying goes, “Watch your thoughts, they become your words; watch your words, they become your actions; watch your actions, they become your habits; watch your habits, they become your character; watch your character, it becomes your destiny.” Conversely, as discussed in section 6.3, digital computers as currently built support no significant Φ-structure, no matter how intelligently they act. They do not exist for themselves, intrinsically, but only for us as conscious observers. Thus, according to the intrinsic powers view, they cannot truly cause nor are they truly responsible for anything. This has important legal implications for how we build and operate them.

9 Some experimental tests

This essay ends with a few considerations about empirical tests. Scientists typically take the extrinsic substrate view (at least implicitly) and tend to see the brain as a complicated biological machine. Like any machine—say, a computer executing a program—the brain cannot help but “run through the motions.” In fact, neurophysiological findings are often presented as supporting the conclusion that free will is illusory. For example, a subject’s decision, such as “I will move my arm,” may be predicted above chance well before the subject “becomes aware of that decision” by recording correlates of neural activity in certain parts of the brain. And indeed, by investigating the brain as a physical substrate that exists and causes as such, it is inevitable that we will only find a series of neuronal events that predict other neuronal events, unrolling along tracks set by neuronal connections. Even if we accept the reality of consciousness and feelings of free will, we must also accept that they emerge upon those neuronal events, that they may emerge late, and that, at any rate, they can play no role in what actually happens. At best, we may find some brain regions that are systematically activated or deactivated when a choice is entertained, a decision is made, and an action is experienced as willed. But we will find nothing that could make any difference above and beyond what neurons have caused.

Figure 11. Human experiments: involuntary vs. voluntary actions, small vs. big decisions. The four panels show paradigmatic scenarios in which the same outward action (hand movement) is performed, but triggered differently. In each case, the neuronal sequence leading to the movement (shown in red) could be recorded using fMRI, high-density EEG, or intracranial recordings. A) The hand moves as a reflex triggered by an automated percussion of the bicipital tendon. IIT predicts that causal analysis should not trace the cause back to the main Φ-structure (blue outline). B) The hand moves due to a direct transcranial magnetic stimulation of the motor cortex (“M1”). Again, the cause should not originate within the main Φ-structure. C) The subject voluntarily moves their hand whenever they “feel the urge” in a Libet-style paradigm. The cause should originate within the main Φ-structure, albeit from a small sub-structure and with low A—corresponding to a free but trivial decision. D) The subject voluntarily moves their hand after pondering which non-profit foundation should receive their donation. The cause should originate from a large sub-structure within the main Φ-structure and have high A—corresponding to a free non-trivial decision.

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\(^{a5}\) This quote has been credited to various historical figures, including Lao Tzu, Ralph Waldo Emerson, and Gautama Buddha. While such figures have made similar statements, the true source appears to be less exotic: Frank Outlaw, founder of BI-LO supermarkets.
If we take IIT’s intrinsic powers view, however, the perspective changes, and not just as a matter of interpretation. Rather, the validity of the intrinsic powers view can be tested objectively by assessing several specific predictions. For example, consider four paradigmatic scenarios in which the same outward action is performed (fig. 1). In the first condition, a subject performs either a left- or a right-hand movement as a reflex triggered by a percussion of the bicipital tendon. In the second, the subject does so due to transcranial magnetic stimulation (TMS) of the motor cortex. In the third, the subject does so voluntarily whenever they “feel the urge,” in a Libet-style paradigm.\(^\text{18, 37}\) And in the fourth, the subject does so voluntarily after deliberating which non-profit foundation should receive their donation.\(^\text{34}\)

These four scenarios can be investigated in humans using functional MRI, high-density EEG, and TMS, as well as intracranial recordings and stimulations. As we have seen, based on the principles of IIT, the main complex should correspond to a maximum of irreducible cause–effect power \((\varphi)\)—and its unfolded cause–effect structure should correspond to a subject’s experience. Ongoing work using approximate measures suggests that it is possible to identify such a maximum of \(\varphi\), primarily over posterior cortical regions. Encouragingly, the same set of posterior regions appear to be critical for consciousness and its various contents based on independent sources of evidence—including lesion, stimulation, and recording studies.\(^\text{22}\) On this basis, it becomes possible to investigate several predictions of IIT that specifically concern free will:

1) Do voluntary actions, but not reflex actions, originate within the main complex in the brain?
2) Is the \(\mathcal{A}\) value higher, and the associated sub-structure within that \(\Phi\)-structure larger, for deliberate actions vs. actions triggered by urges?

In this way, propositions that may at first seem hopelessly “metaphysical”—about the nature of consciousness and true free will—become fully physical (operational) and therefore testable.

10 Conclusion

The argument for true free will presented here depends on IIT as a theory of consciousness, the validity of which must first be evaluated at the conceptual level. Do the axioms fully capture the essential properties of consciousness—that those that are immediately and irrefutably true of every conceivable experience? Do the postulates adequately formulate these axioms into physical, operational propositions? Can the explanatory identity account, at least in principle, for both the essential and the accidental properties of every conceivable experience?

Second, the theory must be evaluated empirically. Does consciousness go along with a maximum of \(\varphi\), associated with a high value of structured integrated information \((\Phi)\)? Does that maximum disintegrate when consciousness is lost? Does the empirical main complex in our brain correspond to such a maximum? Do the units of the main complex in our brain have a grain that maximizes \(\varphi\)? Can the cause–effect sub-structures unfolded from portions of the main complex account for basic aspects of experience, such as spatial extendedness, temporal flow, objects, and local qualities such as colors and sounds?

If IIT survives these empirical tests, then its implications for free will become relevant. What truly exists and truly causes are only intrinsic entities—absolute maxima of cause–effect power, corresponding to conscious beings such as ourselves. Further, if we can consciously formulate alternatives, consider reasons, make decisions, and control our actions, then we have true free will. The amount of free will for any decision can also be measured, and the origin of the decision can be established empirically, thereby providing further tests of IIT.\(^\text{41}\) Finally, if we do have free will, we can perform self-changing and world-changing actions that shape ourselves and our environment according to our intentions. And given the fundamental indeterminism that makes the world open ended in the long run, we can freely shape how we and the world will evolve. For this, we have true and ultimate responsibility.

11 Acknowledgements

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\(^{41}\) Tests in humans are critical, because only in ourselves do we have direct evidence for experience, including the experience of free will. Experiments in non-human primates or rodents may also help the interpretation of human experiments. A complementary approach consists in testing the self-consistency of the IIT account of consciousness and free will using simulated agents \((\text{animat})\).\(^\text{36}\) With such agents, the four scenarios described in humans can be reproduced in a simplified manner to systematically evaluate cause–effect structures and causal accounts. Specifically, we can 1) fully unfold \(\Phi\)-structures and measure their \(\Phi\) value, 2) determine at which spatio-temporal grain the agent exerts a maximum of causal power, 3) back-and forward-track causes and effects while considering their optimal grain, 4) precisely establish whether the distal cause of an action originates within the agent’s substrate, and 5) obtain a causal account and estimate \(\mathcal{A}\)-structures and their \(\mathcal{A}\) value to measure how much the agent causes an action—in other words, to measure the amount of free will it exerts.
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Figure S1. The “unrolled” causal structure of a computer simulating a brain. If one were to apply IIT’s ontological and causal analysis to a computer simulating a cognitive function—say, making a “decision,”—one would find that the computer as a whole does not truly exist as an intrinsic entity. Instead, its causal powers unfold into ontological “dust”—many minuscule entities (specified, say, by small sets of transistors arranged in a cycle, which unfold into tiny Φ-structures [far left]). Moreover, the causal account would fragment into causal “dust”—many parallel causes and effects of very low causal strength $\mathcal{A}$ (shown in red arrows on the cause side and green arrows on the effect side).