A Simulacrum Account of Dispositional Properties

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Abstract

This essay presents a model-theoretic account of dispositional properties, according to which dispositions are not ordinary properties of real entities; dispositions capture the behavior of abstract, idealized models. This account has several payoffs. First, it saves the simple conditional analysis of dispositions. Second, it preserves the general connection between dispositions and regularities, despite the fact that some dispositions are not grounded in actual regularities. Finally, it brings together the analysis and the explanation of dispositions under a unified framework.

1 Introduction

Two distinct problems underlie the longstanding debate over the nature of dispositions. First, there is the question of how to analyze sentences, such as "salt is soluble," which ascribe dispositions to entities. Second, there is the question of how to explain the causal basis underlying a disposition, the properties of salt that make it soluble. I refer to the former task as the *analysis* of dispositions, and to the latter as their *explanation*.

These two problems have been addressed largely independently of each other. Metaphysicians and philosophers of language working within the analytic tradition are generally concerned with the issue of analysis: their target is to provide the truth conditions of disposition ascriptions through a specification of their

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logical form. In contrast, philosophers of science—who are generally interested in dispositions because of their connection to laws of nature[1]—are typically concerned with the explanation of why an object x manifests a disposition to D under conditions C, without entering the dispute on the logical form of these statements. Note that the truth conditions of disposition ascriptions can be specified without presupposing any theoretical account of how dispositions are produced or explained. Indeed, some authors have argued for the possibility of "bare" dispositions that completely lack any categorical basis (Holton 1999). *Vice versa*, explaining the connection between dispositions and laws does not require a common logical form underlying all dispositions: solubility and fragility might have an altogether different analysis, or might not be analyzable at all.

The aim of this essay is to provide a general account of dispositional properties that addresses both their analysis and their explanation. The following section introduces three widespread theses concerning dispositions. I then move on to challenge one of these theses, namely, that dispositions capture regularities in nature. The rest of the essay sketches an alternative view, according to which dispositions are, in fact, grounded in regularities, but they are not ordinary properties of real objects.

2 Dispositions, Conditionals, Regularities

In spite of decades of discussion, little agreement has been achieved concerning the nature of dispositions, how they should be analyzed, or how to explain them. Nevertheless, the following three theses are widely accepted as uncontroversial.

(1) Dispositions are properties of entities.

(2) Dispositions are connected with conditionals.

(3) Dispositions capture regularities.

Thesis (1) is usually taken for granted as a platitude that requires no further motivation. Whether we view dispositions as properties of particulars

[1] As emphasized by Drewery (2001), there is an interesting tension regarding the properties that allegedly hold of laws. On the one hand, laws are traditionally formulated as universal generalizations that satisfy additional requirements, such as being counterfactual supporting. On the other hand, there are general regularities—particularly in the special sciences—that play an explanatory and methodological role analogous to laws of nature, but are not universally valid. Some authors have argued that the predictive and explanatory power of these generalizations derives from their appeal to dispositions, which tend to me manifested, *ceteris paribus*, under general conditions. Such dispositions and capacities are often treated as more fundamental than laws or regularities (Cartwright 1989; Mumford 1998; Lipton 1999). In this respect, dispositions are relevant to the philosophy of science in virtue of the fact that they explain the law-like character of higher-level regularities. The challenge, then, is to explain *how* dispositions can capture high-level regularities, which are produced by causal mechanisms that fall short of being sure-fire things, without thereby trivializing them. The debate over the nature of *ceteris paribus* laws lies beyond the scope of this article. The important point, for present purposes, is simply that the explanation of dispositions is independent of their logical analysis.

(e.g. Hütteman 1998; Mumford 1998; Lipton 1999) or properties of kinds (e.g. Cartwright 1989; Lowe 1989), it seems a brute fact about glass and salt that the former is fragile and the latter is soluble.[2] In contrast, Theses (2) and (3) are supported by philosophical arguments.

To begin, let us focus on the connection between dispositions and conditionals. Intuitively, dispositions entail conditional statements. For example, the fact that a glass is fragile entails that the the glass will shatter, if struck. But what is, precisely, the nature of this relation? Carnap (1936) famously noted some difficulties with providing a logical analysis of dispositions. In particular, he maintained that the "if-then" sentence entailed by a disposition cannot be a material conditional, because lack of a manifestation is not sufficient ground for attributing a disposition to an entity: a glass is not robust just because it is never struck. From this *problem of void satisfaction*, Carnap concluded that dispositions cannot be analyzed in logical terms and attempted to introduce dispositional predicates in the language of science through so-called *reduction sentences*.[3] Other philosophers explored a less radical solution: early in the debate, it was noted that there is a close connection between disposition ascriptions and *counterfactual* or *subjunctive* conditionals. The idea, simply put, is that the fact that a glass is fragile entails that it would shatter, if struck. This observation suggested that dispositions can be analyzed in the following terms:

(SCA) x is disposed to D when C iff x would D if it were the case that C.

This *simple conditional analysis of dispositions* (SCA) has been endorsed by eminent philosophers, such as Ryle (1949), Goodman (1955), Quine (1960), and Mackie (1973). However, there is now a widespread consensus that such analysis is fatally flawed because the connection between disposition and entailed conditional breaks down in cases where objects temporarily lose or acquire dispositions ("finkish dispositions") or when the manifestation of a disposition is "masked" or "mimicked."[4] These problematic cases triggered various reactions. Some authors responded by replacing the simple subjunctive conditional with

[2] To be sure, the thesis that dispositions are properties of entities is only uncontroversial provided that one adopts a "rich" ontology, which—borrowing Lewis' (1986a) terminology—assumes an *abundant* conception of properties. Philosophers who endorse a more minimalist ontology, according to which properties are *sparse*, are more likely to question whether dispositions such as fragility are natural properties. Throughout this article, I presuppose that properties are relatively abundant. I return to this point in the final section and suggest how the present account can be applied to alternative conceptions of "property."

[3] Carnap's method of introducing disposition predicates by means of bilateral reduction sentences faces several difficulties. While such well-known problems need not concern us here, for an excellent discussion, see Malzkorn (2001) and Bird (2012).

[4] Martin (1994) considers a dead wire that is connected to a device that reliably senses when the wire is about to be touched by a conductor and, under those circumstances, makes the wire live by generating a flow of electrons. This *finkish disposition* constitutes a counterinstance to the SCA because, in the imagined scenario, the wire is dead but the conditional "if the wire were touched by a conductor, then it would conduct electricity" is true. Martin also describes specular cases in which the conditional turns out false but the disposition ascription is true, for example, were the finking-device to block the flow of electrons in a live wire every time the wire is touched by a conductor. Cases of *masking* (Johnston 1992) are analogous to cases of finking, except that the object does not lose its disposition, even temporarily; the disposition

a more sophisticated one (Prior 1985; Lewis 1997; Mellor 2000). Yet, all conditional analyses—of the simple or revised form—are thwarted by counterexamples: no matter how stringently one specifies the stimulus-response conditions, it seems that an object can always fail to manifest a disposition (Manley and Wasserman 2008). Other authors explored the possibility of non-conditional analyses (Fara 2005), or abandoned altogether the quest for analysis in favor of non-reductive explanations of dispositions (Bird 1998; Molnar 1999).

While an assessment of these alternative routes lies beyond the scope of this work, we should note that the (alleged) failure of conditional analyses does not entail a rejection of Theses (2) and (3). Indeed, most philosophers—including some who explicitly jettison conditional analyses of dispositions (e.g. Fara 2005)—recognize that there is an intimate connection between dispositions and conditional statements.[5] What seems too strong is Quine's claim that the relation between the antecedent and the consequent of the conditional is one of *necessity*.[6] Moving on to Thesis (3), while the connection between dispositions and regularities is often treated as an implicit assumption, some authors have employed it as the foundation of an alternative account of dispositions. Fara (2005), for example, has suggested that we give up conditional analyses of disposition ascriptions in favor of a non-conditional analysis based on so-called *habituals*—commonsense sentences that describe how an object typically, usually, or habitually behaves ("Mary smokes when she gets home from work").[7] Furthermore, the connection between dispositions and regularities fits in well with the enterprise of many philosophers of science who believe that dispositions are the key to understanding *ceteris paribus* laws or generalizations (see Note 1). After all, even though salt does not always, let alone necessarily, dissolve in water, under most circumstances salt does dissolve in water. This can be taken

is rather extrinsically prevented from manifesting. For instance, one can ingest a lethal dose of poison and yet fail to die, provided that a suitable antidote is timely administered (Bird 1998). Here the poison's disposition to kill when ingested is not lost; it is masked by the action of the antidote. Finally, when an object is induced to manifest the typical behavior without actually having the associated disposition, the disposition is said to be *mimicked* (Smith 1977).

[5]But see Mellor (1974) for an objection to Carnap's entailment thesis.

[6]Necessity is stronger than universality because, while universal generalizations may be contingently true ("No spheres of pure gold are greater than the sun"), necessary truths could not have been otherwise, without violating the laws of logic or physics ("No object travels faster than the speed of light"). However, the fact that salt fails to dissolve when the water is saturated or the atmospheric pressure is abnormally high suggests that the statement "if salt were placed in water, it would dissolve" is not just not necessary; it does not even capture a universal generalization. Thus, in a sense, Quine's analysis got things backwards: while he argued that disposition conditionals are stronger than universal generalizations, the existence of actual (as opposed to potential) exceptions shows that they are weaker.

[7]More precisely, on Fara's view, dispositions cannot be straightforwardly reduced to habituals since, differently from dispositions, habituals can be true "by accident." For instance, it might turn out that, while it usually rains when I leave the house, this has nothing to do with dispositions, either of me or of the weather. To avoid this problem, Fara endorses Lewis' suggestion that dispositions are, at least in part, an intrinsic matter. On this view, an object x is disposed to M when C iff x has an intrinsic property in virtue of which x Ms when C. The details of Fara's proposal need not concerns us here. The important point, for present purposes, is that his account explicitly builds on the claim that dispositions capture some kind of regularities.

to show that what underlies a disposition ascription is a (restricted) regularity; it is the idea of a necessary connection between a stimulus and a response—and, consequently, the SCA—that has to go.

The connection between dispositions and regularities, however, is more troublesome than it might appear at first blush. Some of these difficulties have been overlooked, I surmise, because most authors have focused on a particular subclass of dispositions. To wit, consider some of the paradigmatic dispositions that have dominated philosophical discussions: glass is fragile, salt is soluble, the poison is lethal, barrels are disposed to roll, etc. Despite the apparent diversity in the range of examples, all these dispositional properties have a common characteristic: they tend to be manifested, more often than not, by the entities in question. Under most circumstances, glass breaks when struck, salt dissolves in water, lethal poisons kills when ingested, and barrels tend to roll when pushed. What is the surprise? Is this not what we mean when we say that entities are disposed to break, dissolve, kill, and roll? No. At least not in general, or so I will argue.

3 Dispositions Without Regularities

We are all familiar with examples where a disposition is attributed to an entity (or to a class of entities) in spite of the fact that the entity does not always manifest the disposition, or not all instances of the kind manifest the disposition at all times. As noted, salt is soluble, but it fails to dissolve in saturated water. Less obvious, and more puzzling, are cases in which the connection between dispositions and regularities breaks down: a disposition is attributed to an entity, but the manifestation of the disposition is the exception rather than the rule. Consider a mundane scenario that traces its origins all the way back to Aristotle: acorns manifest a disposition to grow into oaks, when they are planted in soil. The trouble is that, since most acorns simply rot and only a small fraction develops into trees, the connection between disposition and regularity is lost.

A natural reply is that the puzzle only arises because the specification of the conditions under which acorns grow into oaks is too coarse-grained. Once the stimulus-condition "when planted in soil" is spelled out in greater detail, the objection runs, the connection between disposition and regularity will be reinstated. In what follows, I argue that this response is problematic: some dispositions cannot be grounded in regularities, regardless of how precisely the stimulus and response are cashed out. However, given that the precise molecular and ecological conditions underlying the growth of trees are extremely complex and relatively understudied, I will focus on a different example: genes' disposition to be transcribed as RNA. Our deep knowledge of the cellular machinery enables us to frame much more precisely the conditions under which genes display a disposition to be transcribed, as well as the repression mechanisms that may fink, mask, or mimic such manifestation.

What warrants the claim that genes have a disposition to be transcribed?

Here is a simple suggestion: the ascription captures a plain regularity in nature.

(i) Genes' disposition to be transcribed is grounded in the fact that most genes are reliably transcribed as RNA.

Unfortunately, this will not do. The problem is that gene transcription is the exception, not the rule. This is a straightforward consequence of the fact that every cell in an organism derives from the duplication of a single cell (the fertilized egg). Since virtually every somatic cell has exactly the same genome,[8] differences between cell types must depend on patterns of gene activation. The important point, for present purposes, is a corollary of this fact: genes are expressed only when they are required and, at any given time, most genes in every cell are silenced. In this respect, genes are just like acorns: the regularities are idleness and rotting, not RNA and oaks. The upshot is that such dispositions cannot be grounded in actual regularity patterns. Otherwise we would have to conclude, contrary to our initial assumptions, that genes have a disposition to be silenced and that acorns are disposed to rot.

This is where the objection raised above becomes relevant again. Recall, the problem is to reconcile the claim that genes have a disposition to be transcribed with the fact that most genes are silenced. Yet, the logical form of a disposition ascription is not "x is disposed to D," but rather "x is disposed to D when C." The formulation in (i) is misleading because it leaves out a description of the cellular machinery necessary for the transcription of genes. Once we specify the appropriate stimulus, the objection runs, the connection between the manifestation of the disposition and the regularity will be reinstated. Indeed, even a cursory look at the structure of DNA reveals that (and why) the presence of the standard transcription apparatus is necessary but not sufficient for transcription: specific proteins that control the binding of enzymes to DNA and the expression of genes are also required.[9] Thus, perhaps, (i) was too simplistic; the disposition to be transcribed is grounded in a more sophisticated regularity, such as:

(ii) *When all the necessary molecules are present in the cell*, genes are reliably

[8]Exceptions include erythrocytes (red blood cells) and mammalian lymphocytes. However, here we can set these particular cases aside and safely talk as if every cell contains the same genes.

[9]The minimal conditions C required for transcription become clear as soon as we focus on the structure of DNA. Genes have both *structural* and *regulatory regions*, which are constituted of the same material (DNA), but perform different functional roles. The structural portion of the gene codes for the amino acid sequence of the protein. In contrast, the regulatory regions—*promoters* and *enhancers*—do not encode proteins; their function is to regulate gene expression: they determine where, when, and how efficiently the encoded molecules are to be transcribed. More specifically, the role of the promoter is to bind to RNA polymerase—the enzyme that unwinds the DNA double helix and synthesizes messenger RNA (mRNA)—and orient it in the right direction and at the right position (at the "beginning" of the coding sequence) so that it can start the synthesis of mRNA. The second kind of structural region, the enhancer, binds to *transcription factors*, proteins that interact with the promoter to determine when a gene is active and how much mRNA to synthesize. A single gene may have multiple enhancers, each of which can bind various transcription factors, enabling the gene to be transcribed in different conditions and in several cell types.

transcribed as RNA.

The formulation in (ii) clearly represents a step forward from (i). However, even this will not do. The problem, simply put, is that cells have *repression mechanisms* that keep genes silenced even when the entire transcription apparatus is in place.[10] One of the most important and better studied mechanisms of gene repression is *DNA methylation*, which involves the addition of a methyl group to the 5-position of the cytosine pyrimidine ring or the number six nitrogen of the adenine purine ring. The biochemical details of the process are complex,[11] but the underlying idea is straightforward. When the regulatory region (promoter or enhancer) of a gene is methylated, transcription factors fail to recognize it and thus cannot bind it. Since these proteins are necessary for gene activation, methylating the regulatory region of a gene is a successful means for repressing its transcription. DNA methylation is by no means an uncommon phenomenon: recent research suggests that 70-80% of CpG cytosines are methylated in mammals (Jabbari and Bernardi 2004). The conditions for successful transcription thus need to be reformulated as follows:

(iii) When all necessary molecules are present in the cell *and there are no repression mechanisms*, genes are reliably transcribed as RNA.

The formulation in (iii) successfully captures an actual regularity in nature: when the cellular machinery is in place and there are no repression mechanisms, genes are transcribed. The trouble is that we are now very far from the original statement. We started off with a general claim concerning a property of all genes, namely that they have a disposition to be transcribed. What we ended up with is a highly hedged generalization that, while being true of all genes, is realized only under particular conditions, which typically fail to obtain. In addition, and more importantly, there is a worry that (iii) teeters on an analytic claim. Given the heterogenous nature of the various means of blocking gene transcription, the obvious way to give sense to "repression mechanism" is as something which stops transcription. But then the regularity captured by (iii)

[10] We should note that the expression "gene silencing" usually refers to mechanisms other than gene modification (mutations that render the gene inviable). Our focus here is on *epigenetic* processes of gene regulation, processes that do not modify the sequences of nucleotides constituting the gene. Epigenetic gene regulation occurs in two varieties. At the *transcriptional* level a gene is inactivated by making it inaccessible to transcriptional machinery such as RNA polymerase and transcription factors. Genes can also be inactivated at the *post-transcriptional* level, by preventing its mRNA transcript to translate into a protein (by destroying or "blocking" it). Given that post-transcriptional silencing still allows the transcription of RNA, we restrict our attention to regulation at the transcriptional level.

[11] In brief, the process of methylation is triggered by enzymes called *histone methyltransferases* whose action consists in adding methyl groups to histone "tails," i.e. outgrowths that project from their main body and are employed by enzymes to access DNA, even when nucleotides are tightly coiled. The effect of this chemical process is to recruit proteins that condense nucleosomes even more tightly together, repressing transcription of the wrapped gene. Once these methyl groups are removed from the histone tails, the density of the nucleosome (and thus its susceptibility to transcription) returns to its "normal" level, i.e. it returns to the level it had before the methyl groups were added to the tails. Hence, the methylation of a gene is fully reversible.

becomes "genes are transcribed when there are no mechanisms to prevent transcription," which borders on analyticity. Alternatively, one could try to replace the general expression "repression mechanisms" with an extensive disjunctive list describing all these mechanisms, and claim that genes are transcribed when none of these is present. However, there are obvious problems that render this suggestion hopeless. First, the list would be long, cumbersome, and incomplete, since it is more than likely that many forms of gene repression are yet to be discovered. Second, given that different kinds of cells employ different means of repression and not every mechanism works in every cell, a distinct list for every cell-type is required. Finally, these lists would have to encompass not just actual mechanisms, but also all the *possible* ways that organisms might adopt to repress gene transcription. In conclusion, (iii) fails to capture the original insight; we can and ought to do better. In the following section, I suggest a different approach, a general account of dispositions, inspired by the molecular explanation of gene expression, which maintains the connection between dispositions and regularities, as well as a form of the simple conditional analysis.

4 The Simulacrum Approach

Let us take stock. The question driving the discussion is: *what grounds disposition ascriptions?* We began by considering reducing dispositions to subjunctive conditionals of the simple or sophisticated kind, but this attempt was undermined by familiar arguments. Next, we explored the possibility of reducing dispositions to regularities, which is compatible with the observation that objects do not always manifest their dispositions, as long as they do so more often than not. However, this suggestion was thwarted by the example of genes, which are disposed to be transcribed in spite of the fact that most genes are actually silenced. As a desperate attempt to save the connection between dispositions and conditionals or restricted regularities, one might try to argue that dispositions express normative or teleological claims. On this view, a disposition ascription is not a description of what an entity does (more often than not), but a normative statement of what the entity is supposed to do when it functions properly. This formulation has the merit of rendering the idea that dispositions capture some sort of potentiality while, at the same time, explaining the presence of numerous exceptions. Nonetheless, it faces obvious devastating problems. Given that cells require most of their genes to be silenced, it would be absurd to conclude that organisms thrive when most of their genes do not function properly. Similarly, even granting that transcribing RNA is a function of genes and that genes are selected because of their disposition to be transcribed, in general, dispositions cannot be identified with functions. It would be preposterous to maintain that the function of a fragile vase is to shatter when struck. In sum, it appears that dispositions are not grounded in true subjunctive conditionals or regularities, even when these are interpreted as capturing normative statements or function attributions. After all this discussion, we are still left with the problem of understanding what warrants disposition ascriptions.

At this point, one could be tempted to give up on the initial assumption. What molecular biology has shown us, it might be argued, is that we were wrong in the first place in thinking that genes have a *disposition* to be transcribed. Perhaps, genes have an "ability" or a "capacity" to transcribe RNA, but they are not "disposed" to do so. For instance, Levi (1980) draws a distinction between *abilities*—which capture possibilities—and *dispositions*, which capture compulsions. To paraphrase, abilities tells us what *might* happen under certain circumstances, while dispositions tells us what *would* happen, i.e. what is likely to occur in certain conditions. Alternatively, one might attempt to analyze the behavior of genes in terms of *propensities*, dispositional properties that are displayed in probability distributions but may not be identified with objective probabilities (Mellor 1971; Fetzer 1988).[12] This move, however, does not solve the issue at hand because the problem is not specific to dispositions, but applies to any non-categorical property. Propensities, latencies, and capacities—just like dispositions—cannot be analyzed simply on the basis of how frequently they are successfully manifested: dropping a glass that is protected by bubble wrap often enough does not affects its propensity or capacity to break. Hence, even if we stipulate that genes are not disposed, but are rather *capable* of being transcribed, one can readily generate the puzzle by taking the ascribed capacity and finking, masking, or mimicking its manifestation for a sufficient number of times. In short, whether or not an object has a dispositional property depends on intrinsic features of the entity or on extrinsic features of the system in which it is embedded, not on the frequency or probability that the entity displays the relevant behavior.

Let us step back and consider the situation from a slightly different perspective. The claim that genes are disposed to be transcribed is neither about any particular sequence of nucleotides nor about the subset of genes that are transcribed, in appropriate conditions, in an organism or cell. The disposition ascription makes a statement about *all* genes—namely that, under appropriate circumstances, they display a tendency to be transcribed. What grounds this statement is a regularity: genes are regularly transcribed as RNA. Now, as noted, this regularity does not hold in the world since, as a matter of fact, most genes are actually silenced. Nevertheless, in *idealized settings*, when the transcription apparatus is in place, genes are always transcribed as RNA. The aim of this article is to present an account according to which dispositions capture the behavior of abstract models, but they are not ordinary properties of real entities.[13] In what follows, I argue that dispositions are, in fact, grounded in lawlike

[12]Propensities have been the object of recent philosophical analysis, especially with respect to physics (Suárez 2011). Analyzing the relationship between propensities and probabilities constitutes an important philosophical endeavor, albeit one that transcends the scope of this article. As noted below, the present work is mainly concerned with dispositions that fall outside of the scope of fundamental physics.

[13]Here, I am assuming that an entity possesses a dispositional property if and only if the entity satisfies a certain truth conditional analysis. For example, according to SCA, salt is soluble iff it satisfies the subjunctive conditional, i.e. salt would dissolves if placed in water. On the account defended below, real objects do not satisfy the *analysans*, and thus are not the bearers of dispositions. However, the present account can be reconciled with the view that

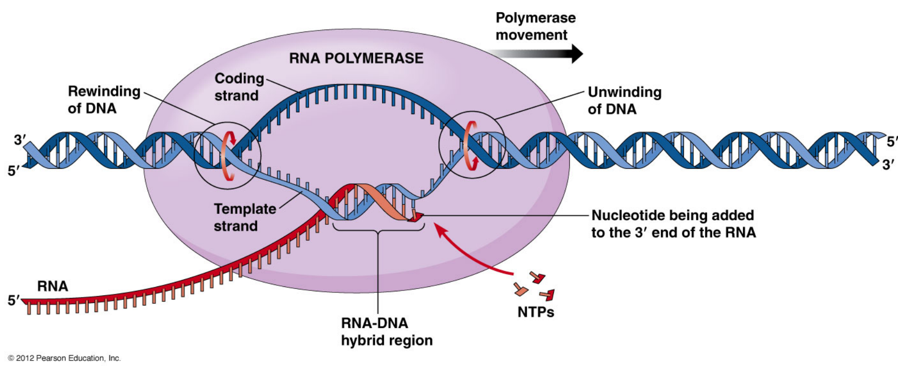

Figure 1: A model of gene expression. (Hardin, Jeff; Bertoni, Gregory Paul; Kleinsmith, Lewis J., *Becker's World of the Cell*, 8th Edition, © 2012. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ).

regularities and can thus be analyzed in terms of subjunctive conditionals. The mistake lies in thinking that such regularities must be actual.

To begin, I should be more explicit about what I mean by "idealized settings." Consider a simple diagram of gene expression taken from an elementary cytology textbook (Fig. 1). Note that this representation of the cellular environment is inaccurate in several important respects. First, it depicts DNA as a free-standing double helix in which all base-pairs are visible and accessible to proteins. Second, all enzymes and transcription factors are assumed to be present in just the right quantity. Third, there are no repression mechanisms, such as DNA methylation, that could potentially interfere with the transcription of the gene. Finally, the cellular environment is represented as a uniform, spacious system in which molecules are free to circulate without impediments. In short, this simplified model represents a set of conditions that turn gene expression into an exceptionless, lawlike regularity: under these circumstances, genes are always transcribed. However, such conditions are seldom or never instantiated;[14] real-life cells are much more complicated. DNA is tightly coiled around histones in ways that often prevent enzymes from interacting with regulatory or structural regions of the gene; methyl-groups "hide" nucleotides from

dispositions are properties of entities, provided that one endorses a weaker notion of property possession. This point will be developed in Section Six.

[14]Whether these conditions are "seldom" or "never" instantiated depends on how strictly we interpret the features of the diagram. On one view, non-methylated DNA instantiates some of the conditions represented in the diagram, while methylated DNA does not. Alternatively, one could say that, while the idealized conditions of the diagram are never instantiated (DNA is never a self-standing double-helix), non-methylated DNA resembles the conditions represented in the diagram more closely then methylated DNA. For present purposes, we need not enter the controversy on model interpretation. The important point is that, in most cases, the cellular environment is relevantly different from the one described in the model and thereby does not exhibit sufficient conditions for gene expression.

transcription factors; proteins necessary for gene expression are often absent or inaccessible; and molecular interactions do not occur in a void. This sophisticated apparatus is what turns real organisms into finely-tuned systems capable of selectively activate genes in the right place at the right time.

These considerations invite a natural question. Why do biology textbooks provide inaccurate representations that are never instantiated in real organisms? The answer is obvious once we recognize that the goal of the model is not to accurately *describe* cells. What the diagram purports to do—and does so quite well—is provide a general *explanation* of gene expression by showing how the underlying processes are instantiated in abstract conditions: when the actual cellular environment suitably resembles the diagram, genes are transcribed. In this respect, the model of gene expression is analogous to the ideal gas law ($PV = nRT$) or the claim that water is H_2O, which also represent idealized conditions that are seldom or never instantiated (no real gas satisfies the law, and pure H_2O is extremely rare outside the lab), but are highly explanatory.

The thesis that describing and explaining are goals that do not generally go hand in hand has been articulated by Nancy Cartwright (1983). In explicit contrast to deductive approaches to explanation, she contends that it is a mistake to assume that most realistic models serve all purposes best; there is a necessary tradeoff between explanatory power and descriptive accuracy. Cartwright maintains that the vast majority of scientific explanations (though she restricts her attention to the physical sciences) are not realistic; too much realism would obstruct the models's explanatory power.[15] This leads her to reject the facticity of laws, the view that laws of nature describe facts about reality. She famously claims that "the laws of physics lie" in the sense that they hold only in highly idealized models that successfully explain—but do not describe—the phenomena accurately. In this essay, I defend an account of dispositions that mirrors Cartwright's approach to explanation, but is completely independent of her view of the fundamental laws of nature. The suggestion is to reject the thesis—often assumed but seldom defended—that dispositions pick out properties of entities. To attribute a disposition to an entity is neither to ascribe a property to that entity, nor to describe a regularity in nature. Dispositions capture the behavior of *abstract models*, artificial constructions that describe the effects that obtain when a system satisfies certain initial conditions.

What is a scientific model? The metaphysics and epistemology of scientific modeling, which has been substantially debated over the last few decades, cannot be adequately addressed here.[16] In what follows, I shall remain agnostic

[15] More precisely, Cartwright distinguishes two senses in which a model can be "realistic." In the first sense, a realistic model represents accurately the situation modeled; it depicts the phenomena precisely. However, a model can also be realistic if it provides an accurate interpretation of its equations. A model is realistic, in this second sense, if it specifies what the mathematical formalism is supposed to represent. Most scientific explanations, Cartwright argues, are not realistic in either sense. This point has been further developed with respect to the debate on the explanatory power of fictions in science (Suárez 2009; Frigg 2010a,b).

[16] While a comprehensive review of this extensive—and growing—literature transcends our present purposes, here is a general overview. At the most fundamental level, *abstract models* can be distinguished from *material models*—physical replicas of an object, such as wooden

regarding the ontological status of model systems and focus on their relation with dispositional properties. Following Giere (1988), I take models to be idealized systems that scientists, as well as ordinary people, use to represent features of the world. More specifically, models mediate the relation between theory and reality; they are employed as explanatory tools that assert a hypothesis claiming a similarity (in relevant respects and degrees) between a theory and a real system. However, Giere's view of models as formal constructions characterized by suitably interpreted equations is overly restrictive. Many scientific models, such as the representation of gene expression discussed above, are not characterized by mathematical formulas. Whether or not suitable equations characterizing these models are, in principle, available is an important question, albeit one that I shall set aside. The important point, for present purposes, is that current science employs models to describe, predict, and explain, and many of these models make no reference to formal equations. In short, while endorsing Giere's notion of models as idealized systems representing the world, I place no restriction on the means of representation, or the need of capturing the "behavior" of the model in precise mathematical terms.

To illustrate, let us return to genes. The ascription of the disposition to be transcribed tells us that, when the conditions in a real cell suitably resemble the idealized model, genes are transcribed. However, the disposition itself is not a property of genes; the disposition captures the behavior of models, like the one depicted in Fig. 1, in which gene transcription constitutes a lawlike universal generalization. Since, in these models, genes are always transcribed, their dispositions can be analyzed in terms of subjunctive conditionals. In sum, disposition ascriptions should not be taken at face value; dispositional properties are not satisfied by real entities. Dispositions are properties that pick out classes of models in which a certain behavior occurs without exceptions. Given the analogy with Cartwright's "simulacrum account of explanation," I refer to the model-theoretic approach defended here as the *simulacrum account of dispositions* (SAD).[17]

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models of planes. The ontological status of abstract models is controversial. According to a popular approach, abstract models are *set-theoretic structures*, i.e. composite entities $S = [U, R]$ consisting of a non-empty domain U of individuals, and a non-empty indexed set R of relations over U (Suppes 1960; van Fraassen 1980; French and Ladyman 1997), or *syntactic items*, such as descriptions or equations capturing a system's behavior. Alternatively, models have been treated as *representations* of a target system analogous to characters of literary fiction (Fine 1993; Elgin 1996; Cartwright 1999; Godfrey-Smith 2006; Frigg 2010a,b). Winsberg (2010) recently offered a somewhat ecumenical perspective, which stresses the role of fictions in modeling while denying the fictional character of models. Just like experimentation, Winsberg says, simulation consists in the manipulation of an object—a model—that stands in for the system of interest; yet the model is not a full-blooded fiction, since it offers a reliable guide to the behavior of the system. For a general discussion, see Frigg and Hartmann (2006).

[17]It is important, however, not to overlook the fact that, as noted above, the present account is completely independent of Cartwright's views regarding explanation and, in particular, regarding fundamental laws of nature.

5 Epistemic Worries

In the first part of the essay, I introduced three claims about dispositions that are often implicitly assumed or accepted as uncontroversial: (1) dispositions are properties of entities; (2) dispositions are connected with conditionals; (3) dispositions capture regularities. By presenting the mechanisms of gene expression, I argued that (3) is problematic: we sometimes ascribe a disposition to an entity even though its manifestation is the exception rather than the rule. Nevertheless, we should not give up (3), for it is hard to see what else might warrant disposition ascriptions other than regularities, given that conditionals, functions, or teleological claims will not do. I suggested that we can retain (3) as long as we reject (1), the pre-theoretical intuition that dispositions are properties of real entities. Dispositions can be analyzed as subjunctive conditionals, they are grounded in regularities, but they only hold in abstract models.

Before discussing the payoff of this approach, there are some potential worries that should be explicitly addressed. In particular, one might argue that the SAD leaves it a mystery why precise facts about theoretical models have applications to bits of the real world. In other words, the objection runs, in ascribing dispositions we intend to advance claims about entities. If, as argued here, dispositions really only hold in models, it is unclear why dispositions are so useful and successful in describing the behavior of real entities and why talk about models leads us to form fairly accurate expectations concerning objects in the world. The problem may not appear to be particularly pressing in the case of dispositions involving genes and other posits of contemporary science. After all, few of us are directly acquainted with DNA or involved in experiments that manipulate it. Given that most of our knowledge of genes comes from textbooks that present us with abstract diagrams, it is hardly surprising that their dispositional properties hold in these idealized settings as well. In contrast, when it comes to macroscopic objects, the idea that dispositions only hold in models becomes counterintuitive. In claiming that salt is water-soluble or that glasses are fragile, we intend to make a statement about salt and glasses, not about diagrams. Furthermore, dispositions lead us to form expectations concerning the behavior of objects. In the case of scientific posits, the link to prediction and expectation is less direct. Surely, in saying that genes are transcribable or that particles are disposed to attract oppositely-charged particles, we expect genes and electrons to behave in a certain way. However, these beliefs are strongly tied to the theoretical framework in which these entities belong. Suppose, for example, that the ascription of "transcribability" was originally based on the belief that genes are regularly transcribed. Still, when geneticists discovered that most genes are actually silenced, they revised the grounds for the ascription and, consequently, the observable expectations. Similarly, were we to learn that some electrons attract each other, we would presumably change our experimental expectations (or, perhaps, we would revise our definition of electron to set counterinstances aside). In contrast, macroscopic dispositions are much harder to revise or give up. Our expectations concerning the behavior of salt and glass are entirely based on direct observation and are largely independent of theories. Hence, when we ascribe solubility to salt and fragility to glass, no corresponding belief is formed concerning what happens to salt and glass in models.

The inference from the truism that dispositions are employed to describe entities (as opposed to models) to the claim that dispositions are properties of entities rests on a misunderstanding of the role of dispositions in ordinary thinking. In many cases, a disposition is posited for lack of a better explanation. Why do we say that salt is soluble? The answer is: to capture the explanation of salt, its tendency to dissolve when placed in water. Note that the disposition ascription does not provide an explanation of this behavior. Dispositions capture general patterns in need of explanation: they deliver explanatory promises, not explanations.[18] Imagine a medieval alchemist observing a grain of salt dissolving in water. His lack of knowledge concerning atomic chemistry prevents him from offering an adequate explanation; nonetheless, he might realize that there is a further story to be told.[19] Furthermore, imagine that at one time he attempts to dissolve salt in what (unbeknownst to him) is saturated water. Given this new evidence, he might conclude that his initial generalization was incorrect: salt is not soluble, after all. Yet, a sophisticated alchemist could conjecture that what prevents salt from manifesting the expected behavior are some extrinsic features of the setting. Since the behavior is manifested under some circumstances but not others, the model that explains such behavior must abstract from certain features of the context that might mask, fink, or mimic the disposition.

Hence, it would be rational for the alchemist to employ the disposition as a placeholder, for lack of a better explanation. But why should *we* refer to salt as soluble, given that we do have access to a proper explanation? The reason has to do with pragmatic convenience and division of labor (Putnam 1975). First, despite being aware that the behavior of salt is due to its atomic structure, most of us ignore the identity and nature of these molecular properties. For example, while knowing that a relatively complete account of solubility is found in many textbooks, I could not readily cite it. Second, it is often convenient to leave the chemical structure unspecified and talk about "solubility" for the sake of brevity or simplicity. For most purposes, the identity of these properties is irrelevant; what is important is that we know that they exist and how they manifest.[20]

[18]This epistemic approach bears important analogies with the "placeholder" view of dispositions, originally developed by Levi and Morgenbesser (1964). There are also noteworthy similarities with the thesis that dispositions are second-order properties possessed in virtue of (first-order) properties, which explain the behavior of entities, but dispositions themselves do not provide any cause or explanation (Prior et al. 1982), and with the thesis that *ceteris paribus* laws express our explanatory commitments (Cartwright 1983).

[19]To be sure, this rational reconstruction is not intended to correspond to an accurate psychological description. It is quite possible for an alchemist to believe that an appeal to solubility constitutes a perfectly adequate explanation of the behavior of salt. Thus, in saying that we should acknowledge the possibility of a deeper explanation, I am appealing to current standards of explanation.

[20]As Levi (1977) notes, the placeholder view does not entail that, for the purposes of satisfactory explanation, dispositions should always be replaced by descriptions of their microstructural bases. While such redescription may be imposed by some research programs (e.g. contemporary analytic chemistry), ascribing dispositions is perfectly adequate for other

Once we realize that dispositions are placeholders for properties that explain the behavior of entities, but the dispositions themselves do not provide any explanation, we are in a position to address the issue raised above: how does the SAD explain why dispositions ascriptions have applications to bits of the real world? The question of how it is possible for properties that are realized in an abstract model to capture the behavior of real entities only arises on the assumption that such properties also cause and explain the behavior of the object. However, if dispositions are placeholders—and thus neither cause nor explain the behavior of entities—the fact that we employ dispositions to refer to the causal basis of real entities becomes unproblematic. When I say that salt is soluble, I am not attributing a property to salt; rather, I am making a claim about how salt would behave under certain idealized circumstances. This subjunctive conditional makes (implicit) reference to a model that we employ to capture the behavior of real salt. This, of course, is not to deny that the ascription of solubility depends on some intrinsic property of salt (i.e. its microstructure). But the dispositional property itself is not a property of salt; it is a property of the model that we use to describe the behavior caused and explained by the microstructure. The objection according to which the SAD makes it a mystery why dispositions are applicable to real entities, is thus guilty of a confusion between attributing a property to an entity and employing a property (that holds in a model) to capture a behavior of the entity. From the fact that a disposition is a property of a model (as opposed to an object), it does not follow that we cannot use the model to describe the behavior of the entity.

Similarly, one might also wonder about the sense in which an ordinary speaker using terms such as "fragile" or "soluble" is *referring* to a model. The potential confusion, I suspect, is due to the technical use of "reference" (extension of a concept), moulded by decades of discussion in the philosophy of language. In claiming that dispositions "refer" to idealized models, I am not committing to any particular stance on the *Bedeutungen* of properties. My point is simply that, in ascribing fragility to glass, people typically have particular circumstances in mind; hence, what renders such claim true or false is the behavior of glass in idealized conditions, not in the world. In this sense, what actually happens to real glass is irrelevant to the ascription, independently of any specific theory of meaning.

The moral that we ought to draw is that dispositions can be used to capture the behavior of real objects such as salt, genes, and glasses, but this does not imply that they are properties of these entities. Dispositions are placeholders for properties that explain the behavior of entities, but the dispositions themselves do not provide any explanation.

What are dispositional ascriptions, then? Are they promises or assertions? In order to address this question, it is important to distinguish between the semantics and the pragmatics of dispositional statements. From a *semantic* point

explanatory purposes. For instance, if we want to explain why Mary added sugar to sweeten her coffee (as opposed to a different sweetener which would not dissolve in the beverage), it is perfectly adequate to appeal to Mary's belief that sugar is soluble. Any further facts about the molecular structure of sugar would be not only unnecessary, but also irrelevant.

of view, dispositions concern solely the properties and behavior of a contextually determined model. Disposition ascriptions can thus be analyzed as follows:

(SAD) x is disposed to D when C iff, in a class of models M, x would D if C

where the identity of M is determined by the context (unless it is made explicit in the attribution). Note that the ascription makes a claim about a class of models; it says nothing about the world. However, from a *pragmatic* perspective, in attributing a disposition to an entity, we convey more than just the existence of a particular class of models; we are also asserting that these models are similar, in relevant respects, to the actual world. In short, dispositions are assertions that describe the behavior of models. The implications about the world—which allow us to employ dispositions to describe the behavior of actual entities—arise from the pragmatic presupposition that a contextually determined model resembles the world in appropriate ways. We are not interested in producing any model; we are looking for models that are useful for the purpose of predicting, explaining, and intervening with real entities in real systems.

Before moving on, two final issues should be explicitly addressed. First, how does the context select the class of models in which the disposition holds? On the present view, the statement "salt is soluble" corresponds to salt always dissolving in water in a class of models M. However, there is also a different class of models $M*$ in which salt never dissolves in water because the pressure is invariably high, or the water is constantly saturated. Why should the conditional be evaluated in M-models, thus concluding that salt is soluble, as opposed to evaluating it in $M*$-models, thus concluding that salt is insoluble? The worry is that, unless we have a non-trivial way of specifying the models in which the conditional holds, the analysis becomes vacuous. This objection misses the target, and it is crucial to see why. True, "salt is soluble" is equivalent to "salt dissolves in water in models M," while "salt is insoluble" is equivalent to "salt does not dissolve in water in models $M*$." However, from the fact that both types of models can be readily produced, it does not follow that the statements "salt is soluble" and "salt is insoluble" are equally warranted or useful for the purposes of predicting, explaining, or intervening with the behavior of salt. As Giere (1988) quite aptly points out, while we can talk of equations and propositions being "true" about models, these truths have little or no epistemological significance because the models are constructed to satisfy precisely these conditions.[21] For instance, in the model of gene expression presented above, it

[21] Here it is useful to borrow Frigg's (2010a; 2010b) distinction between three kinds of statements in connection to fiction, which require different treatment when it comes to question of truth. *Intrafictional propositions* are internal to a fiction and, as a result, we are not supposed to take them at face value, as factual reports. *Metafictional propositions* make genuine claims that can be true or false in the ordinary way; but such claims are restricted to the model: they only hold in the work of fiction. Finally, *transfictional statements* compare features of the model system with features of the target system (bits of the real world.) Applying this to our present account, it is clear that claiming that salt is soluble is "metafictionally true," but trivially so, since the model is constructed precisely to satisfy this statement. What is interesting and important is the "transfictional" claim that the behavior of salt in the model is relevantly similar to the behavior of real salt.

is true that genes are transcribed; but this hardly surprising or illuminating, given that the diagram is intended to capture the conditions for gene expression. The epistemological significance of the model lies not in the propositions or equations that it renders true or false. What makes the model interesting and explanatory is the hypothesis that the theoretical model is similar, in relevant respects, to a real system. Hence, while the simulacrum account does not specify the conditions under which disposition attributions are pragmatically assertible, it subsumes many of the difficulties surrounding dispositions to the general problem of the model-world similarity relation. The nature of scientific representation constitutes a substantial philosophical issue, which is subject to much debate in contemporary philosophy of science (French 2003; van Fraassen 2008), and cannot be adequately addressed here. The important point, for present purposes, is that treating dispositions as properties of models raises no particular epistemic puzzle, in addition to the traditional problem of scientific representation.

Finally, the present account is intended to remain neutral with respect to the nature of the most fundamental denizens of reality. Some philosophers of science have argued that our best scientific theories postulate some basic properties that appear irreducibly dispositional in character. For example, current physics does not reduce the capacity of particles to attract each other to categorical properties.[22] Similarly, the explanation of many chemical reactions appeals to primitive dispositions of molecules to interact with one another. It is important to note that I am not suggesting that these "fundamental dispositions" can be reduced to a categorical basis, nor have I offered any argument to motivate the thesis that such reduction is possible—an important issue, albeit independent of the position defended here. It might as well turn out that the basic constituents of reality are irreducibly dispositional. However, such primitive dispositions would be different from dispositions of ordinary macroscopic objects (salt, glasses), and of those scientific posits (genes) to which the simulacrum approach can be applied. Thus, while endorsing the claim that most dispositions can be analyzed in terms of conditionals and explained in terms of their categorical basis, we can remain agnostic as to whether the most fundamental concepts are particular, local, purely qualitative categorical matters of fact (Lewis 1986b), laws of nature (Maudlin 2007), subjunctive conditionals (Lange 2009), capacities (Cartwright 1989), or something else.

6 Implications

With all of this in mind, I now move on to consider some of the payoffs of the account. First, the simulacrum approach preserves the traditional SCA, which provides the simplest, clearest, and, in my opinion, most intuitive analysis of dispositions. Recall, what undermined the SCA was the possibility of dispositions whose manifestation is finked, masked, or mimicked, severing the connection with the underlying conditional. Here, the disposition holds in a

[22] For an insightful discussion, see the essays collected in Suárez (2011).

class of models in which there are no interfering mechanisms of any sort. In these idealized settings, the conditional holds without exceptions: salt always dissolves in water, fragile objects always shatter when struck, and genes are always transcribed. We can thus provide a straightforward SCA of dispositions, with the explicit proviso that the conditional hold in a class of models, not in the world:

(SAD) x is disposed to D when C iff, in a class of models M, x would D if C.

Before discussing other benefits of the account, let us address a potential worry. Some philosophers have already attempted a defense of conditional analyses of dispositions by appealing to the notion of "ideal conditions." My task is to show that the present approach does not fall victim to the same shortcomings that beset theirs. Consider, for example, the following analysis, suggested by Mumford (1998):

(IC) x is disposed to D when C iff, if x were in *ideal* conditions, x would D if C.

Let us compare the two approaches. In (IC), dispositions are analyzed in terms of subjunctive conditionals that describe what happens to real objects in ideal conditions. Dispositions are properties of entities that are (always) manifested in optimal circumstances where nothing goes wrong. In contrast, (SAD) captures what happens in a class of abstract models that represent the behavior of real entities. The simulacrum analysis does not appeal to *ideal* conditions, but rather to *idealized* models.[23] This subtle—yet significant—difference between ideals and idealizations allows the simulacrum approach to avoid two substantial difficulties undermining (IC): the problem of intrinsic finks, and a trivialization worry.

While Mumford's appeal to ideal conditions successfully screens off "standard" cases of finkish, masked, or mimicked dispositions, (IC) cannot rule out the possibility of *intrinsic finks*: dispositions whose manifestation is hindered as a result of something intrinsic to the entity possessing it.[24] To illustrate, Manley and Wasserman (2008) present a class of examples that show how a disposition can be finked, masked, or mimicked even in paradigmatic manifestation conditions. They envision a sturdy block of concrete that has an "Achilles' heel," i.e. a weak spot: if it is dropped onto a particular corner at just the right angle with exactly the right force, an amazing chain reaction will cause it to break. Although it would be absurd to conclude that the block is fragile, the

[23]These models are a good example of what Weisberg (2007) calls *minimalist idealization*, the practice of constructing theoretical models that include only the core causal factors that make a difference to the occurrence and essential character of the phenomenon in question. Disposition ascriptions guide the construction of these models by selecting the factors required to make the conditional analysis true.

[24]The existence of intrinsically finkish dispositions is controversial. Without entering into the details of the dispute, some authors defend the possibility of intrinsic finks (Clarke 2008; Everett 2009), while others have questioned their plausibility (Choi 2005; Cohen and Handfield 2007; Handfield 2008).

heel mimics fragility under very specific circumstances. These examples thwart any attempt to provide a conditional analysis of dispositions by refining the stimulus and response conditions, or by restricting them to ideal circumstances, since intrinsic finking mechanisms are independent of extrinsic manifestation conditions. In contrast, the SAD has the resources to avoid the difficulty. This is because, even granting that intrinsic finks are indeed possible, such finking mechanisms are not represented in the idealized model. In the diagram of gene expression discussed above, all repression mechanisms that could fink, mask or mimic the transcription of a gene are abstracted away, regardless of whether they are intrinsic or extrinsic. Similarly, the abstract model(s) which capture the robustness of the sturdy concrete block will set aside and ignore any weak spot that interferes with fragility under very special circumstances.[25]

Setting intrinsic finks aside, the second problem with (IC) is that the appeal to unspecified "ideal conditions" threatens to trivialize the whole analysis (Fara 2005). To be sure, Mumford acknowledges the difficulty of spelling out ideal conditions in sufficient detail. In response, he says that even if one cannot specify these conditions precisely, in most cases we have a solid intuitive grasp of what they are. Ideal conditions for salt to dissolve in water include the air pressure approximating that at sea level, the composition of water approximating H_2O, etc. Yet, as Fara notes, unless we have a way of capturing these conditions in general and precise terms, the entire account becomes vacuous. This is because, if ideal conditions are just those conditions in which the disposition is manifested, then the analysans in (IC) reduces to "x would D in conditions in which x would D." This trivialization worry is a substantial one, which ought to be addressed with utmost care. Recall, the goal is to provide an analysis of the sentence "x is disposed to D when C," and this requires a specification of its truth conditions. One way to paraphrase Fara's objection is to say that including an explicit reference to ideal conditions whose truth conditions are left unspecified renders the entire analysis vacuous. Note, however, that the SAD analyzes dispositions *without* appealing to ideal or idealized conditions. The logical form of a disposition ascription is the simple subjunctive conditional "x would D if C." The reference to the class of models is not part of the truth conditions; it just specifies where the conditional holds true, outside of the actual world. The task of specifying these models, whose identity is contextually determined, is not part of the analysis of disposition, but belongs to their *explanation*.

Hence, (SAD) is superior to (IC) in two respects: it successfully deals with the problem of intrinsic finks and it sets the trivialization worry aside. To be sure, the simulacrum approach does not *solve* the trivialization worry, it merely *reduces* it to a broader and independent problem: the world-model similarity relation. A definitive solution would require a general account of the similarity relation, an important issue that, as noted above, cannot be adequately

[25] Manley and Wasserman (2008) also present three additional problems for conditional analyses: (i) the problem of comparative dispositional ascriptions; (ii) the problem of specifying a mechanism for context dependence; and (iii) the problem of absent stimulus conditions. The SAD provides the resources to respond to all three problems; however, addressing these issues in detail would take us too far.

addressed in the present article. Nonetheless, successfully reducing a local problem regarding the analysis of dispositions to a general problem that affects much contemporary philosophy of science, constitutes a significant advancement.

A second benefit of the SAD is that it preserves the connection between dispositions and regularities. Dispositions often capture (but do not explain) a pattern in the behavior of entities under certain circumstances. Ascribing fragility to glasses captures the fact that glasses usually shatter when struck and ascribing solubility to salt captures its tendency to dissolve in water. However, dispositions can also be ascribed when their manifestation constitutes the exception rather than the rule. Acorns have a disposition to grow into oaks and genes are disposed to be transcribed, despite the fact that most acorns rot and most genes are idle. The present approach covers both kinds of attributions. All dispositions can be analyzed in terms of subjunctive conditionals that capture a certain pattern in the behavior of an entity. This regularity is always displayed in abstract models, but does not necessarily correspond to a regularity in the world. When this happens, the aim of the ascription is not to capture an actual regularity, but a behavior manifested under particular conditions which do not, typically, obtain.

Finally, the SAD brings together the analysis and the explanation of dispositions under a unified framework. Clearly, the whole burden is shifted from analysis to explanation. On the present reading, the analysis of dispositions becomes straightforward: the logical form of a disposition ascription corresponds to a subjunctive conditional, with the proviso that such conditionals hold in a class of selected models. The hard task is to associate the behavior of the entity with the right model. But this asymmetry is hardly surprising. Here it is helpful to compare the situation with the related debate in the philosophy of science. As mentioned at the outset (see Note 1), over the past few decades, philosophers have extensively debated the semantic contribution of prefixing a generalization with a *ceteris paribus* clause. The discussion hinges on the difference between "All *Fs* are *G*" and "All *Fs* are *G*, *ceteris paribus*." The important point, for present purposes, is that all competing accounts provide general analyses of cp-hedges by describing their logical form or truth conditions, but none of them specifies the precise conditions under which a particular cp-generalization ("all ravens are black, *ceteris paribus*") is true.[26] And rightly so: such conditions do not follow from the semantic analysis; they need to be investigated individually. Similarly, a semantic analysis of dispositions cannot and need not provide a general criterion for picking out the models in which the conditional holds. Just as there are different pragmatic reasons for hedging a universal generalization

[26]Strevens (2012) divides accounts of *ceteris paribus* hedges into three broad categories. (i) On the *softening* approach, the cp-hedge strengthens the generalization by weakening the connection between F and G. For example, the cp-clause turns the claim "All *Fs* are *G*" into "Most *Fs* are *G*" by identifying a capacity or disposition (Cartwright 1989). (ii) On the *narrowing* approach, the cp-clause strengthens the generalization by weakening its conditions of application. Thus "*Ceteris paribus*, all Fs are G" means "In conditions Z, Fs are G," for an appropriate choice of Z" (Hausman 1992; Lange 2002). (iii) Finally, on the *annotating* approach a cp-hedge has the function of commenting on causal breakdowns (Earman and Roberts 1999).

with a *ceteris paribus* clause, there are various pragmatic reasons for ascribing dispositions to entities.

In conclusion, the simulacrum account has three payoffs. First, it saves SCA. Second, it preserves the general connection between dispositions and regularities, despite the fact that some regularities are not actual. Third, it provides a unified framework for analyzing and explaining dispositions. The SAD, as presented here, is a deflationary view of dispositions, since it rejects the thesis that dispositions are properties of objects. Yet, this account can also be reconciled with the thesis that real entities are the bearers of dispositions, provided that one is willing to endorse a weaker notion of property possession. For example, instead of saying that object x has disposition D iff x satisfies the analysis of D, one could argue that x satisfies D iff the conditional analysis of D holds in the appropriate class of models M. On this reading, dispositions are properties of objects, albeit particular properties whose possession depends on the analysis holding true in a class of associated models. A general discussion of the relation between entities and properties is an metaphysical endeavor that lies beyond the scope of this article. The moral that we ought to draw from the present discussion is that abstract models, not real entities, satisfy the truth-conditional analysis of dispositional properties.

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