

MODELS, CAUSES AND CAPACITIES:
A NEW ACCOUNT FOR LAWS OF NATURE

ÖZER TÜRKER

BOĞAZİÇİ UNIVERSITY

2018

MODELS, CAUSES AND CAPACITIES:
A NEW ACCOUNT FOR LAWS OF NATURE

Thesis submitted to the
Institute for Graduate Studies in Social Sciences
in partial fulfillment of the requirements for the degree of

Master of Arts
in
Philosophy

by
Özer Türker

Boğaziçi University

2018

DECLARATION OF ORIGINALITY

I, Özer Türker, certify that

- I am the sole author of this thesis and that I have fully acknowledged and documented in my thesis all sources of ideas and words, including digital resources, which have been produced or published by another person or institution;
- this thesis contains no material that has been submitted or accepted for a degree or diploma in any other educational institution;
- this is a true copy of the thesis approved by my advisor and thesis committee at Boğaziçi University, including final revisions required by them.

Signature

A handwritten signature in blue ink, appearing to read 'Türker', is written over a horizontal dotted line.

Date 09 / 05 / 2018.....

ABSTRACT

MODELS, CAUSES AND CAPACITIES:
A NEW ACCOUNT FOR LAWS OF NATURE

Humans have reached a consensus about the regularity of nature. However, we have not reached a consensus about what grounds that regularity yet. My thesis tries to address the question of what grounds the regularity of nature. Some philosophers argue that the regularity is in no need of a metaphysical grounding: Regularities in nature are the laws of nature. Other philosophers argue that some regularities in nature are not laws of nature and non-accidental regularities, which are the laws of nature, are indeed in need of a metaphysical grounding: Laws of nature are grounded in the modality-supplying entities. An intriguing figure in this discussion is Nancy Cartwright because Cartwright occupies the middle ground. My thesis argues that Cartwright's account of laws of nature is incomplete, and I try to amend her account by grounding it on a firm metaphysical base. My dissertation tries to expand the discussion about regularities and laws of nature by explicating whether Cartwright's scientifically oriented theory, with a special focus on her idea of "capacities", can be combined with "causal properties" that can be reliably measured. I conclude with a discussion of how the non-accidental regularities in nature cannot ontologically depend on causal properties either for their existence or for their identity.

ÖZET

MODELS, CAUSES AND CAPACITIES:

A NEW ACCOUNT FOR LAWS OF NATURE

İnsanlar doğada düzen olduğuna dair bir fikir birliğine vardılar. Bununla birlikte, doğadaki düzenin altında ne yattığına dair bir fikir birliğine henüz varamadık. Benim tezimin amacı doğadaki düzenin altında yatabilecek ögeleri metafiziksel bakış açısıyla irdelemektir. Bazı felsefeciler bu düzenin altında herhangi bir ögenin bulunmadığını ileri sürmüştür. Onlara göre, doğadaki düzen bizzat tabiat kanunlarıdır. Diğer bazı felsefecilere göre doğadaki bütün düzenli işleyiş tabiat kanunları değildir. Şöyle ki, bazı düzenli işleyişler rastlantısaldır. Rastlantısal olmayan tabiat kanunları mantıksal olmayan zorunluluk sağlayıcıyı ögeler tarafından desteklenmelidir. Bu tartışmada Nancy Cartwright ilgi çekici bir figürdür çünkü Cartwright, iki uç arasındaki ortak zeminde bulunan felsefecidir. Benim tezimin diğer bir amacı Cartwright'in teorisinin tamamlanmamış olduğunu göstermek ve onun teorisini sağlam metafiziksel bir temele oturtmaktır. Ek olarak, tezim, Cartwright'in bilimsel yaklaşımla oluşturduğu teorisinin bilimsel şekilde ölçülebilen nedensel özgülüklerle birleşip birleşemeyeceğini irdeleyecektir. Sonuç olarak, tezimin varacağı yargı, doğadaki düzenin ve tabiat kanunlarının, ne varlıkları için ne de özdeşlikleri için, nedensel özgülükler üzerine ontolojik olarak dayandırılmayacağıdır.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION	1
1.1 What is a law of nature?	1
1.2 The regularity of nature	4
1.3 Laws and properties in the philosophy of science.....	5
1.4 Overview	7
CHAPTER 2: THE LONG-ESTABLISHED ACCOUNTS OF LAWS	11
2.1 The Mill-Ramsey-Lewis (MRL) account	11
2.2 The nomic necessitarian account	16
2.3 Scientific dispositional essentialism	19
CHAPTER 3: CARTWRIGHT'S ACCOUNT OF LAWS	26
3.1 Capacities	27
3.2 Nomological machines	28
3.3 Are there capacities in nature?	29
3.4 Are capacities needed?	31
3.5 The nature of capacities.....	35
3.6 Capacities and laws: The ontological priority.....	37
3.7 Woes and amendments.....	38
3.8 A prolegomenon to a metaphysics of capacities.....	45
CHAPTER 4: A METAPHYSICS FOR CARTWRIGHT'S ACCOUNT.....	48
4.1 Making capacities indispensable.....	49
4.2 Capacities are dispositions after all.....	50
4.3 Analyzing dispositions.....	52
4.4 A prelude to a new metaphysics for capacities.....	62

4.5 Capacities as dispositions: Chakravartty's CPIT to the rescue.....	66
4.6 Capacities as multi-track dispositions: Ability analysis.....	85
CHAPTER 5: CAN POWERS SAVE SCIENTIFIC PHENOMENA?.....	101
5.1 Chakravartty's maximalist approach.....	103
5.2 Chakravartty's naturalized metaphysics: Slippery slope.....	106
5.3 Chakravartty's latest amendment of causal powers.....	115
CHAPTER 6: CONCLUDING REMARKS.....	128
6.1 Laws revisited.....	128
6.2 New directions for Humeans and non-Humeans.....	130
6.3 Final remarks.....	133
REFERENCES.....	134

CHAPTER 1

INTRODUCTION

It is generally believed that laws of nature are non-linguistic phenomena. In particular, laws of nature are not statements that are true or false. Rather, they are regular sequences of event types and truth-makers of law statements. One employs mathematical equations in order to formulate and express laws. Laws are among the ontological components of a mind-independent world.

Nevertheless, the expression of law of nature is an expression of metaphysics, and thus it is a term of art. Philosophers have provided different accounts in order to explicate the notion of law as cogently as possible. Two philosophers among others stand out as quite eccentric in terms of their understanding of the nature of laws: Stephen Mumford and Nancy Cartwright.

1.1 What is a law of nature?

After carrying out a historical and a contextual investigation of the notion of law, Mumford (2004, p. 201) argues that the notion is hitherto employed metaphorically. Expressly, Mumford (2004) contends that only under a theistic worldview one can appeal to the word “law” not only metaphorically, but also literally. Hence, unless there is a theistic outlook, then the use of “law” is merely symbolic according to Mumford (2004). Subsequently, Mumford (2004) illustrates his point thereupon: “The reason we refrain from killing people ... is because it is morally wrong to do; there is a moral law. Metaphorically, then objects attract electrostatically ... because of the ‘law of nature’ makes it so” (p. 202).

In a counterintuitive manner, according to Mumford (2004), there is no need for a natural law because dispositions, which are causally efficacious properties, render laws otiose. Mumford (2004) concludes thusly:

There does not need to be anything that is added to the world to keep it in order and regular. So, the law metaphor provides no enlightenment. The world is interconnected, self-regulated, if you must, by the internal relations of its properties. (Mumford, 2004, p. 204)

That is, according to Mumford (2004), even a metaphorical use of “law” is redundant. Thus, Mumford (2004) suggests dispensing with the notion completely in the fields of science and the scientific metaphysics.

Cartwright (2016) agrees with Mumford’s aforementioned argument.

According to Cartwright (2016, p. 2), the term “law” is merely a metaphor.

Nonetheless, it is a misleading one. Expressly, the term conjures up a phenomenon that is immutable, universal and entirely explanatory, but the order in the universe is not all-encompassing.

Let us briefly present two traditional and one relatively nascent accounts of laws, respectively. In all likelihood, the most well-known stance regarding laws is empiricism. Two prominent supporters of this view are David Hume and David Lewis. According to empiricists, there is logical necessity alone. That is, one thing does not lead to another. In nature, there are just bundles of states of affairs that appear to be orderly. The force, which I experience regularly, when my thirty kilograms cousin hits me is lesser than the force when my ninety kilograms uncle hits me. Such regular phenomena give rise to the empiricist idea of law: Laws are regularities. Do laws govern? No, they do not.

“All the presidents of the United States are above five feet tall” is a statement of regularity, but not of a law. As an empiricist, Lewis (1986, p. 9) contends that some regularities, e.g. Newton’s Second Law, are more privileged than the others

because of the privileged regularities' much broader scope. What is more, privileged regularities are descriptively simpler (i.e., simplicity) and explanatorily more encompassing (i.e., strength) than non-privileged regularities. Such privileged regularities are laws of nature.

Another widely known account of laws of nature is nomic necessitation. " $F = ma$ " expresses a law because there are abstract entities, namely the universals of force, mass and acceleration, which are related specifically.¹ Unlike empiricists, supporters of nomic necessitation think that laws are, in a non-logical sense, necessary because universals necessitate lawlike relations. Unlike universally quantified statements that do not express laws, " $F = ma$ " is a law statement because the abstract figures of force, mass and acceleration need to relate whereby $F = ma$. On the other hand, it is not necessary for universals "being a president of the United States" and "being above five feet tall" to be paired whereby "All the presidents of the United States are above five feet tall". This account is criticized on the ground that it is unable to determine the property of lawhood that are peculiar to laws, but not to accidental generalizations (or "accidents" for short).

As to the other stances of laws, both Mumford's and Cartwright's theories belong to Aristotelianism. Their views are radical because their methods of investigation require, in Kuhnian terms, a paradigm shift whereby we should no longer search for laws.² Rather, we should try to enhance our understanding of what causal powers or capacities of properties are. Hacking (1983) argues that scientific activities are twofold: (i) representing and (ii) intervening. Cartwright (1998) underlies the importance of the second aspect by focusing on "what a property empowers an object to do" (p. 25). Unlike laws of nature, Cartwright (1998) thinks

¹According to Armstrong (1983, p. 96), the relation is nomic necessity.

²Cartwright (1997, p. 69) calls the traditional method the law-first view.

that laws of science describe capacities of physical systems, including objects. Electrical systems, in virtue of possessing electrical charge, have the capacity to attract or repel any other system that possesses electrical charge. Under suitable conditions, manifestations of capacities give rise to the regularities that we observe in the world.

However, Aristotelianism is not problem-free either. One metaphysical question that should be answered is: What are capacities, causal powers and dispositions? One epistemological (and metaphysical) question that should be answered is: Given that capacities are real, then how are they individuated? Unless these questions are answered satisfactorily, both Cartwright's and Mumford's arguments seem to be problematic. Cartwright (1989) is aware of this problem: "For the testing of causal claims at any level ... necessarily presupposes some metaphysical assumptions that cannot be tested by the same stringent logic" (p. 180). In the fourth chapter of this thesis, I will try to provide a firm metaphysical ground for Cartwright's notion of capacities by combining her account with dispositional essentialism and (multi-track) dispositions.

1.2 The regularity of nature

It is a truism that there are regularities in nature. Making generalizations is possible due to such regularities. So far so good. Following this clarification, a vexing question emerges: Why are there regularities in nature? This question is partly a metaphysical one. Psillos (2014, p. 10) likewise contends that there are two central metaphysical stances concerning the regularity of nature. One of them is the empiricist stance: It is a brute fact that there are regularities in nature. The other one is the rationalist stance: The regularity of nature is in need of a metaphysically

deeper and robust explanation. A chief aim of this thesis is to express and explicate the long-established accounts of laws that belong to the aforementioned stances, and then argue for the strengths of the metaphysically least weighty account. Arguing against metaphysically weighty accounts by conceptual analysis may seem paradoxical at first glance. However, I prefer to follow Psillos's (2014) motto: "[I]f metaphysics is inevitable, I prefer to follow Herbert Feigl's advice: 'If this is metaphysics, make the least of it'" (p. 26). I aim to show that laws of nature are not in need of a deep (or "thick") metaphysical grounding by establishing that a typical method of metaphysical grounding (i.e. invoking causal powers, dispositions or capacities) is incoherent. In particular, I will try to argue that anti-realism concerning causal powers or dispositions does not stem from the fact that such powers are not observable with one's unaided senses. Rather, I will try to argue that they are not real because they are undetectable. Expressly, I subscribe to the view that positing causal powers for explanatory reasons is an ad hoc maneuver concerning the metaphysics of laws (cf. Chakravartty, 2010).

1.3 Laws and properties in the philosophy of science

One way to categorize Humeans and non-Humeans about laws is based on their understanding of fundamental properties. Most Humeans (e.g., Lewis, 1973; Ramsey, 1978) take such properties as categorical: Properties have characteristic molecular or chemical structures alone. On the other hand, there is the view of dispositional essentialism according to which all fundamental properties have dispositional essences (cf. Harré & Madden, 1975; Ellis, 2001; Bird, 2007; Chakravartty, 2007). There is more to come on this division in the fourth chapter of this thesis.

As noted in the sub-heading 1.1, dispositional essentialism shifts the method of analysis about relation between laws and properties diametrically, thereby, unlike Humeans, nearly all dispositional essentialists consider dispositional properties or dispositions as more fundamental than laws whereby dispositional properties ontologically ground laws.

Although Cartwright's idea of capacities is in line with that of dispositional essentialists, Cartwright is not widely considered to be a dispositional essentialist. There are signs of Cartwright's being a dispositional essentialist after all. Chakravartty (2003, p. 409) discusses one of them whereby Cartwright's arguments regarding *ceteris paribus* laws can be interpreted as realist remarks about dispositions. Even Cartwright (2007) herself explicitly underlies this possibility. Specifically, dispositions or capacities are often posited as real entities because of their unificatory role concerning causation, properties and laws.

A disposition, which is a causally efficacious property according to nearly all dispositional essentialists, can explain why there are regularities in nature, and, how laws, which are the causal relations between properties according to Cartwright (1989, 1999) and Chakravartty (2003, 2007), provide scientific knowledge. Chakravartty (2017) strives to establish that dispositions are among the ontological components of the universe. I first aim to evaluate Chakravartty's (2017) argument concerning his reasons for being a realist about dispositions. Subsequently, I will try to show that instead of establishing, Chakravartty (2017) simply assumes the existence of dispositions. The aforementioned views and arguments will be explicated in detail in the fourth and fifth chapters of this thesis.

1.4 Overview

Here is the final road-map of this thesis. In the next chapter (Chapter 2), I will discuss the long-established realist accounts of laws of nature in detail, including the best systems account of Lewis (1986), and the universals (or the nomic necessitation) account of laws, to which Armstrong (1983), Dretske (1977) and Tooley (1977) (henceforth, ADT) subscribe. These accounts search for an understanding of the property of lawhood, which is steered by the idea that laws are universal and counterfactual-supporting generalizations. Armstrong (1983) and van Fraassen (1989) raise objections against the best systems account. After the explication of those objections, the thesis will turn to the shortcomings, which are pointed out by van Fraassen (1989) and Carroll (1990), of the ADT account.

The new wave of neo-Aristotelianism constitutes a radical break from the Humean metaphysics of laws. The paragon of neo-Aristotelianism is dispositional essentialism. Supporters of this account include Swoyer (1982), Ellis and Lierse (1994) and Ellis (2001). Earman (1984) is likely to be one of the most prominent critics of dispositional essentialism. This thesis will also evaluate the accounts of dispositional essentialism in detail. The fact that there are numerous conflicting accounts of laws shows that it might be unlikely to reach an agreement concerning the metaphysics of laws.

Cartwright (1998) thinks that instead of the law-first view, we should adopt the power-first view. Cartwright is an exemplary philosopher in terms of her efforts to show that the traditional understanding of lawhood is misguided. The third chapter of this thesis (Chapter 3) will entirely be devoted to the explication of Cartwright's (1989, 1999) arguments. Although it is widely held that Cartwright is not keen on providing a thick metaphysical ground for her theory of laws, she nevertheless

employs a language that appeals to several metaphysical notions such as capacities, nomological machines, etc. The chief problem with Cartwright's theory seems to be that she aims to argue for a metaphysical account by appealing to scientific practice (i.e., the structure of scientific models) alone. Our explication will mainly focus on Cartwright's theory of capacities. Cartwright is a controversial figure and her arguments are meticulously criticized by Morrison (1995), Psillos (2002) and Hoefer (2003). Despite Cartwright's seeming reluctance, one should amend Cartwright's theory by grounding it on a firm metaphysical base. Otherwise, her power-first methodology would not be fruitful in the first place. Searching for a metaphysical ground for Cartwright's theory will be the central aim of the fourth chapter.

In the fourth chapter (Chapter 4), I will try to combine Cartwright's account of capacities with dispositional essentialism. In the literature, the terms "capacities", "causal powers" and "dispositions" are often used interchangeably. Moreover, Cartwright (2007b) highlights the likelihood of such a combination. Indeed, there are nuances to Cartwright's account that should be explicated rigorously. At the end, such nuances might prevent one from combining capacities with conventional dispositions. Psillos (as cited in Cartwright, 1999) brings about the possibility that capacities can be taken as Shoemaker's (1980) "conglomerates of powers" (p. 70). Indeed, capacities, powers and dispositions all refer to causally efficacious phenomena. Unless the nuances in Cartwright's account are explicated (and altered accordingly), capacities will remain *sui generis*. I will try to establish that if Cartwright's notion of capacities is taken in its original state, then capacities can most suitably be combined with multi-track dispositions. If the nuances of Cartwright's notion of capacities are altered accordingly, then capacities can be combined with conventional dispositions. Vetter (2013) and Williams (2011) are

among the realists concerning multi-track dispositions. Even if one grounds Cartwright's account on thick metaphysical powers or dispositions, it will still not be clear whether laws concern what capacities are in the world and how those capacities relate to one another under idealized circumstances, as Cartwright (1999, p. 59) argues.

How should we analyze powers, capacities or dispositions conceptually? Psillos (2014) contends that "an ontological thick conception of powers" is the conception to which he is against because such a conception is not the "direct consequence of the foregoing ordinary way to accommodate talk about powers in everyday life and in science" (pp. 12-13). Indeed, we can talk about capacities or causal powers liberally as long as we do not commit ourselves to an idea that scientific practice aims to discover the nature of such powers (cf. Chakravartty, 2010; Cartwright, 1989). Even the interchangeability of the terms "powers", "capacities" and "dispositions" is an indication of those terms' vagueness. Given that capacities are real, then how are they individuated? How are they manifested? What are they specifically? These are among the questions to be evaluated in the fifth chapter (Chapter 5). Chakravartty (2007, 2010, 2013b, 2017) is one of the most exemplary supporters of an "ontological thick conception of powers" due mainly to their explanatory and unificatory functions (Psillos, 2014, p. 12). In the fifth chapter, Chakravartty's (2010, 2013b, 2017) arguments will be explicated and criticized. In that chapter, I will try to show that appealing to scientific practice in order to show the reality of a metaphysical entity (i.e., causal powers or capacities) is a category mistake. I will also try to establish that Chakravartty (2017) falls short of justifying his thick conception of powers. Appealing to powers or capacities in terms of

developing an account of laws is a metaphysically weighty and an ad hoc option – to which I firmly stand against.

The sixth chapter (Chapter 6) will be the concluding chapter. That chapter will start with the concluding remarks, thereby the thesis will be evaluated holistically. After the explication of the aforementioned accounts in terms of their strengths and weaknesses, I will try to subscribe to the least metaphysically weighty and the most coherent option, namely the best systems account, as the most cogent outlook. Last, I will argue that philosophers should continue to develop and amend their theories of laws in line with the Humean tradition, as Psillos (2014) has already done.

CHAPTER 2

THE LONG-ESTABLISHED ACCOUNTS OF LAWS

As discussed in the sub-heading 1.1, there are regularities that are not laws, and not vice versa. Maxwell's laws of the electromagnetic field and the laws of ideal gases are genuine laws of nature. "All coins in my pocket are dimes" is not a law statement after all.³ Therefore, laws are regularities with a characteristic property. What is this "characteristic property"? It is a property that can help us distinguish between the true and universally quantified statements that do not express laws, and, the statements that express laws.

Specifically, one can contend that the logical form of a statement that expresses a law is: It is a law that all *F*s are *G*s if and only if (i) if all *F*s are *G*s and (ii) "L". According to Lange (1993, p. 1), the element "L" is the property of lawlikeness (i.e., lawhood). What exactly is lawlikeness? Traditional theories concerning laws have strived to find a cogent answer to this question, thereby we can understand the nature of lawlikeness. Now, let us explicate one of those theories in detail.

2.1 The Mill-Ramsey-Lewis (MRL) account

One approach to differentiate between genuine laws and accidents is the Mill-Ramsey-Lewis account (MRL). Ramsey (1928, p. 131) aptly argues that, unlike accidents, laws play an important role as general axioms in the context of the

³Reichenbach (1947) gives an example about this apparent problem: "All gold cubes are smaller than one cubic mile" (p. 368). The statement appears as a lawlike statement, but it is not a bona fide nomological statement. van Fraassen (1989) calls these sorts of problems that face Humeans "the problem of identification" (p. 39). The problem has an ontological and an epistemological facet. The former concerns the identification of "L" (i.e., the fact that makes "It is a law that *p*" true.) The latter concerns singling out nomological statements.

deductive-nomological (DN) model of explanation. Lewis (1973) similarly contends that “a contingent generalisation [*sic*] is a law if and only if it appears as a theorem (or axiom) in each of the deductive systems that achieves a best combination of simplicity and strength” (p. 73). In a nutshell, a regularity in isolation cannot qualify as a law. A regularity can qualify as a law if and only if it belongs to a “system that can be represented as a deductive axiomatic system striking a good balance between simplicity and strength” (Psillos, 2002, p. 149). The more a theory is informative about regularities in the world, the stronger it is. Simplicity is a principle of parsimony whereby otiose axioms and fundamental laws are differentiated. Lewis (1973) knows that simplicity and strength do not always go hand in hand:

The virtues of simplicity and strength tend to conflict. Simplicity without strength can be had from pure logic, strength without simplicity from (the deductive closure of) an almanac ... What we value in a deductive system is a properly balanced combination of simplicity and strength – as much of both as truth and our way of balancing permit. (Lewis, 1973, p. 73)

When a situation at hand is puzzling, Lewis (as cited in Psillos, 2002) advises that we must consider all possible sets of combinations of simplicity and strength “on the assumption that we know everything” (p. 150). Then laws would be those regularities that are expressed by the theorems and the axioms, which are members of all possible true deductive systems of simplicity and strength. Nevertheless, there is at least one such system, which combines simplicity and strength, to which, say, “ $F = ma$ ” belongs as an axiom or a theorem. Newton’s Second Law is not only relatively simple, but it is also highly strong whereby one can drive, say, both Kepler’s laws of planetary motion and the work-energy theorem. If there is at least one system of this type, then it is likely that the world has innumerable alike true deductive systems.⁴

⁴Psillos (2002, p. 150) ponders this possibility.

It follows from Lewis's first argument that his answer to the second horn (i.e., the epistemological problem of identification) of the dilemma about the problem of identification is that laws are the axioms or the theorems that are members of all true deductive systems, whereas accidents are not. As to the first horn, one can infer that the property of lawlikeness is peculiar to the regularities in the best systems alone.⁵

2.1.1 Woes and amendments

First, do vacuous laws have truth-makers? In light of the best systems account, it seems that they do not. Lewis might eschew this question since according to empiricists, laws must be actual regularities and Lewis is an empiricist. If accepting such laws into the best systems increases the strength of such systems without decreasing their simplicity, then those vacuous laws can be included.⁶

Second, what does make the statement "It is a law that all *F*s are *G*s" true? One initial answer may be that a mind-independent fact in the world makes it true. According to Lewis (1973), belonging to the best systems as an axiom or a theorem does the job because, as noted, a regularity in isolation cannot qualify as a law. Carroll (1990) points out a related flaw. Carroll (1990) contends that Lewis's principle is "relative to the present-day state of knowledge and our current cognitive interests" (p. 202). In other words, Lewis's principle seems to be epistemic and the principle seems to depend on our subjective (i.e., mind-dependent) interests regarding the axiomatization of knowledge. Thus, some philosophers, including

⁵Psillos (2002) formalizes Lewis's (1973) argument as follows: "It is a law that all *F*s are *G*s if and only if (i) all *F*s are *G*s, and (ii) that all *F*s are *G*s is an axiom or theorem in the best deductive system Φ (or, if there is no unique best deductive system Φ , it is an axiom or theorem in all deductive systems that tie in terms of simplicity and strength)" (p. 151).

⁶Psillos (2002) contends that "[vacuous laws] must arise in the attempt to account in the strongest sense and simplest way for actual regularities" (p. 152).

Carroll, think that Lewis does not give a cogent answer to the ontological side of the problem of identification.

One major virtue of the empiricist attitude is that empiricists take that our knowledge of the world is fallible. Indeed, the history of science has justified this attitude. As an example, Newton's Second Law is true only in its specific context of application (i.e., inertial reference frames). Hence, even though the criterion of lawlikeness might be subjective, the best systems account takes laws as mind-independent such that laws are laws irrespective of our cognitive attitudes towards them. Is Lewis's criterion of "nomicity" subjective? Ramsey (1928) and Psillos (2002) think that it does not need to be. Following Ramsey (1928), Psillos (2002) contends that "it is a fact about the world that some regularities form, objectively, a system; that is, that the world has an objective nomological structure, in which regularities stand in certain relations to each other" (p. 154). Psillos's (2002) and Ramsey's (1928) amendments provide a cogent answer to the ontological problem of identification: Laws are distinct from accidents because it is a fact that there is an "objective nomological structure" in the world.

Third, Armstrong (1983, p. 69) aptly observes that Lewis's (1973) theory cannot account for counterfactual conditionals because there is only logical necessity according to Humeans, including Lewis. What is more, Dretske (1977) criticizes Lewis's account concerning this problem whereby, say, a lawlike generalization "all metals expand when heated" implies "something about the actual [metals] and [expansion] in this world. It says absolutely nothing about those possible worlds in which where there are additional [metals] or different [metals]" (p. 266). This flaw of the MRL view is a serious one.

Fourth, some philosophers, including Psillos (2002, pp. 154-55), criticize Lewis's criterion of simplicity on the ground that the predicates that we employ regarding the wording of axioms or theorems determine the simplicity of a true deductive system. One amendment is to distinguish between "artificial" and "natural" properties such that the latter refer to real properties, whereas the former do not. According to Lewis (1983), we should leave out "artificial" predicates (e.g., the Goodmanian predicates such as "grue" or "artificial" disjunctive predicates such as "x is Q if and only if x is F or G.") However, Lewis's characterization could complicate the problem. Expressly, how is it possible to categorize natural properties unless there is some sort of nomic necessity in the world? Lewis (1983, pp. 347-48) thinks that certain pair of objects bear resemblance to each other due to being observed and they are called "particulars". Indeed, there are numerous different types of particulars that are observed to be yellow and/or human. Thus, "being yellow" and "being human" are natural properties according to Lewis (1983). Is Lewis's criterion that distinguishes between natural and artificial properties is cogent?

It seems to be cogent because if "representation" and "intervention" are the two fundamental aspects of scientific practice, as Hacking (1983) thinks, and, if natural properties are reducible to scientific "physical magnitudes", as Hall (2010) thinks, then the scientific method of observation, together with the scientific method of detection are two promising ways for further investigation in terms of determining natural properties.⁷ If the antecedent of the previous sentence is true, then this flaw of the MRL view is not serious. Determining the truth-value of the antecedent is beyond

⁷Maudlin (2007) is a prominent critic of Hall's (2010) idea concerning the reduction of (perfectly) natural properties to physical magnitudes. This topic is beyond the scope of this thesis. However, it is indeed promising to follow this route in order to amend the MRL account, specifically Lewis's (1973) version, against the epistemological problem of identification.

the scope of this thesis. Nevertheless, as Armstrong (1983, pp. 68-69) argues, each and every account of laws should strive to explicate the nature of properties.

2.2 The nomic necessitarian account

Non-Humeans think that all Humean accounts, including the best systems, fall short of solving the two facets (i.e., the ontological and the epistemological) of the problem of identification.⁸ Specifically, as for the ontological problem, non-Humeans contend that the truth-maker of a lawlike proposition such as “It is a law that $F = ma$ ” must be mind-independent because being a regularity or belonging to the best systems does not explain why the aforementioned lawlike proposition is true. As for the epistemological problem, they think that our true deductive systems with strength and simplicity do not have the objective characteristic that allows us to distinguish authentic nomological statements from accidents.

Unlike Humeans, nomic necessitarians, who are non-reductivists, aim to deal with the ontological problem by arguing that laws, unlike accidents, reveal some sort of necessitation relation between universals. Armstrong (1978) contends that “ F -ness necessitates G -ness, or being F necessitates being G ” (p. 149). Moreover, according to Armstrong (1978), laws are intrinsically different from regularities whereby the former cannot be reduced to the latter, and vice versa. By dispensing with Lewis’s empiricism, Dretske (1977), Armstrong (1983) and Tooley (1977) contend, with certain differences, that a law is a nomic necessitation relation between universals, say, F -ness and G -ness (i.e., $N(F,G)$).⁹ This is the ADT account. Psillos (2002) expresses the ADT account formally as follows:

⁸Put accurately, non-Humeans are not satisfied with the Humean answers, including Lewis’s (1983), concerning the problem of identification.

⁹Especially, Tooley’s (1977) version is quite different from Dretske’s (1977) and Armstrong’s (1983).

It is a law that all *F*s are *G*s if and only if there is a relation of nomic necessitation $N(F, G)$ between the properties (universals) *F*-ness and *G*-ness such that all *F*s are *G*s. (p. 163)

In light of this account, a nomological statement “All salt, when in water, dissolves” is true because the universals “being salt in water” (denoted by “*F*”) and “dissolving” (denoted by “*G*”) are related by nomic necessitation (i.e., “*N*”), thereby all salt, when in water, dissolves (i.e., “ $N(F, G)$ ”).¹⁰ The notion of necessitation of the ADT account is a sui generis metaphysical modal notion in the sense that the relation of nomic necessitation is not a logical necessity (i.e., there may be possible worlds in which the relation does not hold.) What is more, the relation is determinable a posteriori, thereby laws are categorically different from tautologies. Although in our world it is the case that “being salt in water” necessitates “being dissolved”, there may be a world in which tokens of “*G*” does not follow tokens of “*F*” regularly. Nonetheless, the notion of nomic necessitation seems quite indeterminate thus, it is in need of further explication.

Armstrong (1993) later strives to shed light on his notion of nomic necessitation. According to Armstrong (1993), no universal can exist unless it is instantiated. As noted, a universal can be known a posteriori and it can have numerous instances such as “being yellow”, “being light”, “being dissolvable”, etc. What is more, according to the ADT account, when universals are related via nomic necessitation the particulars that have such universals are also related accordingly. Specifically, according to Armstrong (1983, 1993), the relation of nomic necessitation is a second-order relation (i.e., a universal) that range over first-order universals (i.e., properties), which in turn range over particulars. There is more to come on this topic and its related issues in the next sub-heading.

¹⁰This example shows how the nomic necessitarians try to solve the ontological problem of identification.

2.2.1 Woes and amendments

First, van Fraassen (1989, p. 39) aptly observes that the ADT account must address the inference problem. In particular, the ADT view should show how the relation of nomic necessitation (i.e., “N”) works. In other words, how does “F-ness necessitates G-ness” entail “All Fs are Gs” (Armstrong, 1978, p. 149)?¹¹ If Armstrong (1978) holds that the relation automatically provides a nomic necessitation between individuals, then he should give a further explication of the nomic necessitation relation whereby the inference problem can be solved.

As noted in the previous sub-heading, Armstrong (1993) contends that the relation of nomic necessitation is a second-order universal, or relation, because higher-order properties, such as the nomic necessitation, are needed to distinguish laws of nature from accidents. Armstrong (1993) further elucidates that the necessitation relation “is the very same relation that is actually experienced in the experience of singular causal relations, now hypothesized to relate types not tokens” (p. 422). Subsequently, Armstrong (1997b, p. 507) contends that the relation is identically causal. Furthermore, in a non-Humean manner, Armstrong (1993) thinks that singular causal relations are identified a posteriori. At this point, Armstrong is confident that his account is amended.

Armstrong’s confidence seems to be ill-founded. Initially, Armstrong (1993) liberally assumes, similar to the MRL theorists, that his notion of nomic necessitation can distinguish between natural and artificial properties, thereby the predicates of law statements would refer to natural properties alone.¹² Indeed, Armstrong (1978) provides an argument to amend his theory. However, Carroll (1990, pp. 200-01) does not find that argument cogent. In addition, Earman’s (1984, p. 217) counterargument

¹¹Put formally, it must be shown that $N(F, G) \rightarrow \forall x(Fx \rightarrow Gx)$.

¹²This is about the epistemological problem of identification that challenges Humean regularists.

weakens the force of Armstrong's (1983, 1993) account because by contending that necessitation relations, to which laws belong, are discoverable a posteriori, Armstrong (1993) cannot account for the laws that refer to unobservable entities. These counterarguments are seriously damaging.

Second, Psillos (2002, p. 171) contends that Armstrong's (1983) theory cannot account for conservation laws (e.g., the law of conservation of energy). van Fraassen (1989, pp. 109-16) thinks that Armstrong's (1983) theory falls short of establishing the existence of probabilistic laws (e.g., atomic decay). Such problems, which are seriously damaging Armstrong's view, are tightly correlated with Armstrong's notion of higher-order properties and relations.

Third, van Fraassen (1993, p. 436) thinks that given that singular causal relations are discoverable a posteriori, the inference problem persists since only by fiat one can show that such relations between particulars also hold identically between universals. This last objection might be the most damaging one because it leads to the conclusion that Armstrong's (1983, 1993) argument concerning the nomic necessitation relation is ad hoc. The ADT account, in particular, Armstrong's (1983, 1993) account, does not only fall short of providing a plausible solution to the identification problem, it also faces an additional problem (i.e., the inference problem) that it has not addressed cogently yet.

2.3 Scientific dispositional essentialism

According to the MRL and the ADT accounts, laws of nature are metaphysically contingent. Expressly, there are possible worlds in which laws differ. Recently, there has been a revival of the Aristotelian powers, which are grounded in the natures of things, in the field of scientific metaphysics. Some philosophers, who can be labelled

as neo-Aristotelians, think that such powers render laws metaphysically necessary. Put differently, neo-Aristotelians contend that laws entail counterfactual conditionals and there are regularities in nature because laws, which are grounded in the natures of things (i.e., the inner principles of change and being at rest), bring about the regularities in nature.¹³ By following the Kripkean revolution, neo-Aristotelians argues that the existence of metaphysically necessary truths (e.g., water = H₂O or if there is water, then it is H₂O) discoverable a posteriori is rooted in the natures of things in virtue of which laws hold metaphysically necessarily.¹⁴ As noted, although the ADT view accounts for the existence of the regularities in nature through the relation of nomic necessitation, the problem of inference undermines the force of its argument heavily.

Dispositional essentialism is the epitome of neo-Aristotelian stances in scientific metaphysics. According to dispositional essentialism, laws are metaphysically necessary.¹⁵

Prominent defenders of this view include Ellis (2000, 2001), Bird (2001, 2007) and Chakravartty (2003, 2007).¹⁶ According to dispositional essentialism, there are natural kinds with causal powers, i.e., intrinsic metaphysical modalities, whereby such kinds are disposed to behave as they do necessarily (Ellis, 2000).

A body, in virtue of its mass, has the tendency to attract other bodies with mass. Under appropriate circumstances, such bodies attract necessarily.

¹³See Bodnar, I. (2018). Aristotle's natural philosophy. The Stanford encyclopedia of philosophy. Retrieved April 13, 2018, from <http://plato.stanford.edu>.

¹⁴Lowe (1998, pp. 8-21) and Ellis (2000, pp. 335-37) are among the neo-Aristotelians who subscribe to the notion of metaphysical necessity. Accordingly, Swoyer (1982) contends that the natures or properties "give rise to the law without the need for any additional relation" and then adds that "the very natures of [*F-ness*] and [*G-ness*] make it impossible for there to be a world in which [*'All Fs are Gs'*] is false" (pp. 216-18).

¹⁵All dispositional essentialists do not think that laws are metaphysically necessary (cf. Mumford, 1998, 2004).

¹⁶Bird (2007) should be considered as a "strong" dispositional essentialist. This notion will later be elaborated in the sub-heading 2.3.

More importantly, according to dispositional essentialism, there is no possible world in which there is a body with mass and it fails to attract any other massive body.¹⁷

Humean metaphysics and dispositional essentialism are diametrically opposite stances. First, the latter rejects the former's argument that laws supervene on "a vast mosaic of local matters of particular fact[s]" (Lewis, 1986, p. ix). Rather, the latter states that if the natures of things are fixed, then laws will also be fixed due to their ontological dependence on such natures. Second, the former supports, in Cartwright's terms, the law-first view, whereas the latter supports the power-first view. Expressly, according to Humeans, a thing is of a natural kind due to its properties and the laws that govern it. On the other hand, dispositional essentialists contend that things have properties, at least some of which are dispositional, that determine the laws that govern them.¹⁸

All dispositional essentialists are realists about causal powers, dispositions, capacities or propensities. However, there are subtle differences concerning their accounts of properties, causal laws, as well as their ideas of the relation between scientific practice and causal powers. Ellis (2000, 2001) is hitherto considered as the epitome of dispositional essentialists. This thesis now turns to a brief examination of how Ellis (2000, 2001) differs from other prominent dispositional essentialists such as Bird (2007) and Chakravartty (2007). Initially, Ellis is an essentialist about natural kinds. What is a "natural kind" specifically? Ellis (2009) contends that it is just a simple fact of the world: "There appears to be an immense hierarchy of natural kinds, that is, natural kinds whose instances are 'substances'" (p. 51). In other words,

¹⁷Ellis (2000) argues that: "The causal laws are not contingent universal generalizations about how things actually behave, but necessary truths about how they are intrinsically disposed to behave" (p. 344).

¹⁸One dispositional essentialist of this idea is Ellis (2000, pp. 340-41).

natural kinds (e.g., chemical kinds) are real, universal and have real essences (i.e., essential properties).¹⁹

Neither Bird (2007) nor Chakravartty (2007) employs the Ellisian notion of natural kinds substantially, but only of natural dispositional properties. According to Ellis (2001), dispositions, dispositional properties or irreducible causal powers of natural kinds of tropes partly determine their real essences, which in turn determine the laws that govern them. Unlike Bird and Chakravartty, Ellis is not a strong dispositional essentialist. “Strong” and “weak” dispositional essentialists differ from each other in terms of their understanding of what kind of properties there are. Strong dispositional essentialists contend that there are no categorical properties but only dispositional ones, whereas weak dispositional essentialists admit that some properties are categorical.

As for causal laws, Ellis (2009, p. 63) contends that since categorical properties (e.g., spatiotemporal properties), together with the dispositional ones, determine the real essences of natural kinds, in turn laws of nature, categorical properties are necessary for laws. Notwithstanding, after presenting his conditional analysis of “natural” and “fundamental” dispositions, which are the truth-makers of law statements, Bird (2007, p. 46) argues that, given that there is an apparent stimulus, dispositional essences by themselves give rise to laws. Both Ellis (2001) and Bird (2007) contend that laws are metaphysically necessary due to being determined by causal powers. Chakravartty (2007) is a “strong” dispositionalist but his view also differs from that of Bird (2007). Expressly, Chakravartty (2007) argues that laws are not metaphysically, but naturally necessary: “Nothing precludes the possibility that laws might have been different, because the [dispositional] properties

¹⁹Morphological similarity among entities is not sufficient to classify them as one and the same natural kind according to Ellis (2009, pp. 51-59).

of the actual world, presumably, are not themselves metaphysically necessary existents” (p. 130).

As for the relation between scientific practice and causal powers, all three, more or less, agree that dispositions are real, and, science strives to study and understand the manifestations of such dispositions. Ellis (Bigelow, Ellis & Lierse, 1992) argues as follows:

We argue that included among the essential properties of a property is the propensity or disposition of whatever possesses it to display a particular kind of behaviour in a specific kind of context. What science observes and codifies are the manifestations of these dispositions. (Bigelow, Ellis & Lierse, 1992, p. 378)

Although Chakravartty (2009) considers the possibility that the term “scientific metaphysics” is an oxymoron, he still thinks that metaphysics simpliciter “may yield insights worth having, especially when done in conjunction with an awareness of our best science” (p. 75). What is more, despite trying to refrain from referring to scientific practice in his defense of the reality of dispositions, Chakravartty (2007, p. 69) asserts that when we “seek the truth in Newton’s theory of gravity”, we realize that there are likely to be dispositions at work. Bird (2007) is bolder than Chakravartty in terms of his direct appeal to scientific practice in order to establish the reality of dispositions. Specifically, Bird (2007) claims that “a metaphysics designed to further our scientific understanding of nature [is needed]” (p. 202).

2.3.1 Woes and amendments

In this sub-heading, I will try to explicate the weaknesses and the strengths of dispositional essentialism by focusing on Ellis’s (2001, 2009) arguments exclusively. First, as noted, Ellis (2000, 2001) appeals to essential properties in order to determine the laws. Some of those properties are essentially dispositional.

Dispositions or causal powers may be explanatorily powerful because such powers can ground the lawlike regularities in nature. Thus, if dispositions are real, they can solve the ontological problem of identification. Specifically, the statement “It is a law that all heated metals expand” is true because metals have the causal power to expand when heated intrinsically. It is in virtue of that power that the lawlike regularity holds in all possible worlds with heated metals.

As for the epistemological problem, nomic statements are categorically different from accidents because, unlike accidents, nomic statements express laws that are metaphysically necessary because essential dispositions determine such statements. Therefore, dispositions can account for counterfactual conditionals and explain lawlike behaviors in nature. So far so good.

However, given that dispositional properties are real, then: (i) how can we distinguish essential properties from the “non-essential” ones; and (ii) how are such properties individuated? Unless Ellis gives non-question begging answers to these questions, his account will be deeply flawed.

Second, instead of showing that there are real causal powers, Ellis (2001) simply assumes that there are such powers and then contends that there are regularities in nature in virtue of causal powers. What is more, Ellis (as cited in Bigelow et al., 1992), argues that scientific practice is concerned with “the manifestations of these dispositions” (p. 378). As Psillos (2006) rightly points out, scientific practice cannot give us a metaphysical account of properties. All accounts of properties and causal powers are and should be given through conceptual analysis. This serious problem also weakens the force of Chakravartty’s (2007, 2017) realist argument of causal powers, which will be explicated thoroughly in the fifth chapter of this thesis.

Third, Ellis (2009, pp. 53-54) initially contends that it is merely a simple fact that there are natural kinds, whose reality is metaphysical (i.e., natural kinds are not discoverable empirically), thereby such kinds explain regularities in nature. Moreover, a real essence is a necessary condition for there to be a natural kind. There are two problems here: (i) although Ellis (2000, pp. 335-37) previously contends that metaphysically necessary truths are discoverable a posteriori, Ellis (2009, p. 51) later argues that natural kinds, which eventually give rise to such truths, are not; and more importantly (ii) unless there were real essences, there would be no natural kinds, in turn there would be no “immense hierarchy of substantive natural kinds.” Ellis (2000) does not propose a criterion to determine what essential properties are and how they are individuated. Thus, Ellis (2000) does not establish that there are real essences. Even if there are such essences, it is apparent that only in few sciences there will be natural kinds with real essences, e.g., chemistry (cf. Chakravartty, 2007). These three problems seriously weaken the force of Ellis’s (2000, 2001, 2009) arguments whereby they render causal powers and real essences mysterious.

CHAPTER 3

CARTWRIGHT'S ACCOUNT OF LAWS

Cartwright's philosophy of science is one of the most explicated views among the views of active philosophers of science. Psillos (2008) aptly explains Cartwright's prominence as follows:

Many empiricists thought that because empiricism has been traditionally antimetaphysics, it has to be antirealist. One of the major contributions that Cartwright has made to philosophy of science is, I think, precisely this: [T]here is a sense which metaphysics can be respectable to empiricists. Hence, scientific realism cannot be dismissed on the grounds that it ventures into metaphysics. To be sure, the metaphysics that Cartwright is fond of is not of the standard a priori (or armchair) sort. It is tied to scientific practice and aims to recover basic elements of this practice (e.g., causal inference). But it is metaphysics, nonetheless. (Psillos, 2008, p. 167)

In other words, Cartwright is a highly important philosopher in the contemporary philosophy of science. The reason is that, despite being an empiricist, Cartwright (1989, 1999) contends that scientific discoveries show that our world contains qualitative causal structures and singular causes. Then let us explicate Cartwright's general philosophy of science briefly whereby one can understand her account of laws completely. Cartwright (1983, p. 89) is an entity realist who contends that there are mind-independent theoretical entities. Cartwright (1999) argues that there is no small set of fundamental or theoretical laws and then adds: "It is not realism but fundamentalism that we need to combat" (p. 23).

In a nutshell, Cartwright's (1999) metaphysical thesis is that our world is "dappled" (i.e., every region of the world is not orderly.) What is more, all-embracing laws, which are assumed in the DN models of explanation, do not exist. Capacities (i.e., first-order or second-order properties) of things, which are grounded in such things' *natures*, give rise to laws only under idealized circumstances. Hence,

there is a gap between reality and the *ceteris paribus* laws that govern under certain conditions. Nomological machines bridge this gap by suitably manipulating factors of a system whereby laws can occur. Cartwright tries to formulate and explicate her arguments in the books *Nature's Capacities and Their Measurement* (1989) and *The Dappled World: A Study of the Boundaries of Science* (1999), respectively. In her first book, Cartwright (1989), without conceptually explicating her notion of capacities, tries to show that we are ontologically committed to capacities due to their function in scientific explanation. In her later book, Cartwright (1999) tries to explicate what capacities are. In the next sub-heading, following Psillos (2002), we will try to give an in-depth analysis of Cartwright's argument.

Before going further, it is important to note that Cartwright's argument is not only eccentric, but also abstruse. One reason is that although her account of laws is in need of a metaphysical grounding, Cartwright does not provide a substantial one. If interpreted coherently, Cartwright's arguments (1989, 1999) can bring about a metaphysically satisfying story of natural laws. However, as Psillos (2008) contends, "it is metaphysics, nonetheless" (p. 167).

3.1 Capacities

According to Cartwright (1989, 1999), capacities are ontologically prior to laws because the world is not orderly in its entirety. Expressly, nearly all laws are *ceteris paribus* thus, the Humean notion that there are exceptionless regularities (i.e., all-encompassing laws) is not cogent. In a counterintuitive manner, Cartwright (1999, pp. 27-28) asserts that some regions of the world are not governed by any laws at all. In order to augment the force of her argument, Cartwright (1999, pp. 11-12) contends that scientific practice supports her *patchwork* view of laws. It has already been

noted that it is a truism that there are regularities in nature. By denying the universality of laws, does Cartwright commit herself to strong anti-realism concerning regularities? No, she does not.

In order to understand Cartwright's notion of laws, let us explicate her metaphysics in detail. Unlike Humeans, Cartwright (1999, p. 81) contends that the ontological commitment to all-encompassing laws is unfounded; rather, there are only objects, which are collections of properties, with inherent capacities or causal powers. In virtue of such properties, objects can behave in certain ways, e.g., an electron, in virtue of its negative charge, can repel or attract other electrons under varying circumstances. Thus, it is a likely story that capacities, which are parts of objects' natures, are abilities to behave in characteristic ways. So far so good. However, what is Cartwright's notion of laws? Now, let us turn to Cartwright's patchwork view of laws and her notion of nomological machines.

3.2 Nomological machines

Cartwright (1999) contends that if a certain region of the world appears orderly, then there is an operating nomological machine, which is described as follows:

[A] fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behaviour that we represent in our scientific laws. (Cartwright, 1999, p. 50)

Laws hold *ceteris paribus* because there are nomological machines in nature. For example, it is a universal law that the planetary orbits are approximately elliptical on the conditions that there are no other interfering planets and the sun is a perfect sphere. Hence, it is a conditional law. Cartwright (1999) argues that our solar system

is a natural nomological machine, which ensures that circumstances are right whereby it is a regularity that the planets move in ellipses.²⁰

In order for a nomological machine to ensure regular behaviours, not only “fixed (enough) arrangement of components” and “right sort of stable (enough) environment”, but also “stable (enough) capacities” are necessary (Cartwright, 1999, p. 50).²¹ Indeed, Cartwright (1995) does elucidate the intricate relation between capacities, nomological machines and regularities (or laws) such that: “[T]he point is that the fundamental facts about nature [(i.e., nomological machines)] that ensure that regularities [(i.e., laws)] can obtain are not again themselves regularities. They are facts about what things can do [(i.e., capacities)]” (p. 154). Now, the thesis turns to *Nature’s Capacities and Their Measurement* (1989) in order to analyze Cartwright’s (1989) argument concerning why science cannot explain without capacities.

3.3 Are there capacities in nature?

As noted, Cartwright is not fond of a thick metaphysics. Nonetheless, Cartwright (1989) argues that empiricists fall short of providing a cogent theory concerning the results of scientific practice thusly:

I advocate giving up [radical-empiricist image of science] entirely – especially it seems not to work – and accepting that capacities and causings are real things in nature. There is I think no other view of nature that can give an adequate image of science. (Cartwright, 1989, pp. 167-70)

²⁰According to Cartwright (1999), there is regularity if and only if there is a nomological machine, which ensures that all the other things are equal. Cartwright (1999) contends as follows: “[L]aws of nature (in this necessary regular association sense of ‘law’) hold only *ceteris paribus* – they hold only relative to the successful repeated operation of a nomological machine” (pp. 49-50). Natural nomological machines (e.g., the planetary system) are exceedingly rare such that “more often [nomological machines] are engineered by us, as in a laboratory experiment” (Cartwright, 1999, p. 49).

²¹One example of a capacity is: “[A] force has the capacity to change the state of motion of a massive body” (Cartwright, 1999, p. 51).

Alternatively, Cartwright's (1989) argument is grounded in the methods of science. It is important to note that Cartwright's (1989) argument has a descriptive and a normative aspect. As for the former, Cartwright (1989) appeals to what scientific practice actually consists of. As for the latter, Cartwright (1989) appeals to what scientific practice should consist of if it claims to offer us "a far more powerful picture of why science works, both why its methods for finding things out make sense and why its forecasts should ever prove reliable" (p. 36). According to Cartwright (1989), causal capacities make science work such that "capacities ... make things happen, case by case" (p. 3). Hence, Cartwright contends that scientific practice should appeal to capacities.

Let us examine Cartwright's (1989) argument in detail. Cartwright's central thesis is threefold, but only the two of them are included in the scope of this thesis: (i) the Humean notion of causation is misleading since capacities' singular manifestations result in singular causal laws; and (ii) capacities should not be regarded as a metaphysical mumbo jumbo by empiricists because they can be measured reliably. Subsequently, Cartwright (1989) endeavors to establish that science does not need natural laws because natural laws' traditional role is ultimately shouldered by capacities.

Cartwright (1989) is a realist about singular causes. According to Cartwright (1989), causality cannot be reduced to probability increase per se. Nevertheless, she adds, an increase of probability in a homogenous sample shows that there are causal interactions in operation. The reason is that unless a single cause brings about its effect in certain cases, then the related probability will not increase.²² After evaluating singular causes, Cartwright (1989) arrives at a conclusion as follows:

²²This thesis mentions Cartwright's (1989) argument of singular causes merely to show the link between her notion of capacities and of singular causal laws. Cartwright's notion of causation in its

A single successful case is significant, since that guarantees that the causal factor does indeed have the capacity it needs to bring about the effect. That is why the generic claim and the singular claim are so close. Once the capacity exhibits itself, its existence can no longer be doubted. (Cartwright, 1989, p. 136)

In other words, since the single cause in question can (and once did) bring about its related effect, the existence of a capacity is shown according to Cartwright (1989).

What is more, Cartwright (1989, p. 163) argues that, irrespective of circumstances, a capacity possesses the ability to bring about its effect. That is: *C* (i.e., a cause) brings about *E* (i.e., an effect) in a single situation; *C* possesses the capacity to bring about *E*, thus whenever *C* is present the probability of *E*'s occurrence will increase in every other situation. Last, Cartwright (1989) concludes that capacities are real because they are explanatorily powerful, and they help us make strong inductive arguments.

3.4 Are capacities needed?

Following Psillos (2008, pp. 180-86), let us explicate Cartwright's (1989) argument in more detail concerning why science cannot work without capacities. First, Cartwright (1989, pp. 162-63) appeals to Sellars's (1963) argument in order to establish that capacities are real. In more detail, Sellars (1963) contends that *levels picture* view of theories is deeply misguided.²³ This view, in a nutshell, posits that theories explain scientific phenomena indirectly – by appealing to theoretical frameworks in order to explain the generalizations grounded in the observation

entirety is not discussed in detail in this thesis. In a nutshell, especially in the first three chapters, Cartwright (1989) appeals to linear causal modeling and path analysis in order to incorporate single causal factors into capacities whereby capacities can be measured reliably. Hence, according to Cartwright (1989), capacities are indeed detectable and measurable thus, they are real. The reader will decide whether Cartwright's (1989) related arguments are compelling.

²³Rosenberg (2007) aptly explains this view as follows: "[I]dentification of scientific explanation with logical derivation, according to which singular matters of particular fact are explained by deducing descriptions of the term from 'inductively-established' empirical generalizations along with appropriate statements of initial conditions, and such 'empirical laws' in turn are explained by deducing them from theoretical postulates and correspondence rules" (p. 35).

language. Sellars (as cited in Psillos, 2008) criticizes this picture on the ground that an empiricist may contend that “all the explanatory work vis-à-vis the bottom level is done by the observational framework and its inductive generalizations” (pp. 180-81). Rather, we recourse to theoretical entities in scientific practice because “[theoretical entities] also explain ... why ... some observable entities do not behave the way they should, had their behaviour been governed by the observational generalisation [sic]” (Psillos, 2008, pp. 180-81). Cartwright (1989, p. 163) follows Sellars’s (1963) method in order to argue for the opposite conclusion (i.e., the reality of capacities). At first, Cartwright (1989, p. 160) formulates the picture, to which Sellars (1963) is against, with an additional “capacities” layer, as given in Table 1:²⁴

Table 1. Levels Picture View of Theories about How Theories Explain

Non-modal stage	Stages of generalization
Regularities	Associational laws
	Causal laws
	Capacities

Note: This table is adapted from *Nature’s capacities and their measurement*. (p. 160), by N. Cartwright, 1989, New York, NY: Oxford University Press.

Later, Cartwright (as cited in Psillos, 2008) contends that such a formulation can mislead one to dispense with the higher (i.e., causal) level because: “All the explanatory work [could] be done by Humean laws, endowed with modal force” (p. 181). If that were the case, Cartwright (1989) observes, the higher causal level would merely be an unreal modal level, a linguistic expression to talk about the Humean

²⁴Specifically, Cartwright (1989) distinguishes between the two higher levels of modality (i.e., “causal laws” and “ascriptions of capacity” or capacities) such that: “[T]he concept of general *sui generis* causal truths – general causal truths that are not reducible to associations – separates naturally into two distinct concepts, one at a far higher level of generality than the other: [A]t the lower level we have the concept of a causal law; at a higher, the concept of capacity. I speak of two levels of generality, but it would be more accurate to speak of levels of modality, and for all the conventional reasons: the claims at both levels are supposed to be universal in space and through time, they support counterfactuals, license inferences, and so forth” (p. 142).

laws. Cartwright's (1989) stance is to the contrary. That is, it is rather the case that only through the higher causal level we can coherently explain the regularities in nature. Thus, the mere modal account of capacities is unlikely due to "ceteris paribus conditions involving interactions" and "the need to control for multiple capacities associated with the same feature" (Cartwright, 1989, p. 163).²⁵

Secondly, in addition to the stage of "causal laws", Cartwright (1989) posits the level of "ascriptions of capacity" because causal laws are "local kinds of causal claims" whereby such laws are "relative to a particular test population" (p. 144). Expressly, according to Cartwright (1989), although causal laws are not mere frequencies, their operation is relative to a homogeneous population.²⁶

As noted, the highest stage of generalization (i.e., capacities) is needed because a capacity has the power to manifest its canonical behaviour in all circumstances. The statements that express causal laws are universally quantified because, according to Cartwright (1989), there are capacities that explain and universalize such statements as follows:

Obviously a concept stronger and more general than the (relativized) causal laws just introduced. Of course, one can de-relativize: [D]o not consider 'Cs cause Es in T' but rather 'Cs cause Es', *simpliciter*. But what does this de-relativized claim say? There is a specific answer to that for the relativized version, an answer already apparent from the argument above. If the relativized law is true, then in T some Cs will produce Es, at least on average, or in the long run, or however one wants to read probability. What about the non-relative version? I think it reports that Cs – by virtue of being C – can cause E. In short, C carries the capacity to produce E. I think that in part

²⁵Cartwright (1989) further explains her argument as follows: "I have argued already that, one modal layer down, *ceteris paribus* conditions on the inference patterns licensed by causal laws cannot be specified without already invoking strong notions of causality. Causal interactions are interactions of causal *capacities*, and they cannot be picked out unless capacities themselves can be recognized. The attempt to 'modalize [sic] away' the capacities requires some independent characterization of interactions; and there is no non-circular account available to do the job" (p. 164). The force of this assertion will be explicated in the next sub-heading of this thesis.

²⁶According to Cartwright (1989), a casual law such as "Smoking causes cancer" is not identical to increase in probability per se in a particular test condition. Rather, smoking brings about cancer because, in the first place, there is a causal law "Smoking causes cancer" in virtue of which the probability increases in a homogenous population, which specifies the conditions of the causal ascription (e.g., age group, lifestyle, genetic predisposition, etc.)

because the universal quantifier involves just the kind of reasoning that is appropriate to capacities. (Cartwright, 1989, p. 145)

Cartwright (1989) contends that capacities are stable such that although causal laws are *ceteris paribus*, capacities remove the *ceteris paribus* clause such that:

“[C]apacity is something they can be expected to carry with them from situation to situation. So if the probability goes up in one test situation, thus witnessing to the capacity, it will do the same in all the others” (p. 145). If aspirin exhibits once its capacity to relieve headaches, then aspirin relieves headaches simpliciter.²⁷ What is more, in addition to their stability, capacities are reliably measured in virtue of the analytic method according to Cartwright (1999). Cartwright (2002) later explicates the analytic method thusly:

We commonly use the analytic method in science. We perform an experiment in ‘ideal’ conditions, *I*, to uncover the ‘natural’ effect *E* of some quantity, *Q*. We then suppose that *Q* will in some sense ‘tend’ or ‘try’ to produce the same effect in other very different kinds of circumstances. This procedure is not justified by the regularity law we establish in the experiment, namely ‘In *I*, $Q \rightarrow E$ ’; rather, to adopt the procedure is to commit oneself to the claim ‘*Q* has the capacity to *E*’. (Cartwright, 2002, pp. 435-36)

In other words, Cartwright (2002) contends that if, under “idealized conditions”, in “one good single case” *Q* brings about its effect, then “*Q* has the capacity to *E*.”

Thirdly, Cartwright (1989) argues that there are causal interactions, which allow us to make generalizations, that are grounded in causal capacities: “Causal interactions are interactions of causal capacities, and they cannot be picked out unless capacities are themselves recognized” (p. 164). For instance, a fatal car crash, which involves my car, occurs and then my airbag deploys. Such a crash has the

²⁷Cartwright (1989) elucidates herself on capacities’ single exhibition thusly: “‘Aspirins relieve headaches.’ This does not say that aspirins always relieve headaches, or always do so if the rest of the world is arranged in a particularly felicitous way, or that they relieve headaches most of the time, or more often than not. Rather it says that aspirins have the capacity to relieve headaches, a relatively enduring and stable capacity that they carry with them from situation to situation; a capacity which may if circumstances are right reveal itself by producing a regularity, but which is just as surely seen in one good single case. The best sign that aspirins can relieve headaches is that on occasion some of them do” (p. 3).

capacity to kill me. However, the deployed airbag, which has the neutralizing capacity to block the capacity of the crash, saves me. Thus, a causal interaction occurs according to Cartwright (1989).

Overall, Cartwrights gives these three arguments in order to establish that science cannot work without real capacities. In the next sub-heading, we will try to evaluate the force of those arguments thoroughly. Now, let us turn to *The Dappled World: A Study of the Boundaries of Science* (1999) in order to analyze Cartwright's argument concerning the nature of capacities.

3.5 The nature of capacities

In order to understand what capacities are, we should first individuate capacities ontologically. That is, what makes capacities the capacities they are (i.e., the distinct object "capacity" or the kind "capacities") must be singled out. In the first place, Cartwright (1989) gives us a hint about this issue in the form of an example: "[T]he property of being an aspirin carries with it the capacity to cure headaches" (p. 141). Then, according to Cartwright (1989), it seems that first-order properties (e.g., "being an aspirin") have capacities to bring about their related effects. Ontologically speaking, unless capacities are sui generis ontological kinds, then one plausible account of capacities will be that capacities can be explained in terms of properties of properties (i.e., second-order properties).

Properties carry capacities. But, what does "carry" mean? Cartwright (1989) asks: "Does this mean that there are not one but two properties, with the capacity sitting on the shoulder of the property which carries it? Surely not" (p. 9). It is important to note that capacities have not been individuated yet. Cartwright (1999) later addresses this issue. Expressly, Cartwright (1999) contends that: "Coulomb's

law describes a capacity that a body has qua charged” (p. 53). “Qua” means “in the capacity of” (The Oxford English Dictionary, n.d.) according to *The Oxford English Dictionary*.²⁸ When it is replaced, the statement becomes: “Coulomb’s law describes a capacity that a body has in the capacity of being charged.” Then the property of “being charged” is itself a capacity according to Cartwright (1999), i.e., capacities are first-order properties. What is more, Cartwright (1999) adds thereupon:

Attraction, repulsion, resistance, pressure, stress, and so on: [T]hese are concepts that are essential to physics in explaining and predicting the quantities and qualities that we can directly measure. Physics does not differ from ordinary language by needing only some special set of occurrent property terms or directly measurable quantities stripped of all connections with powers and dispositions. Rather, what is distinct about the exact sciences is that they deal with capacities that can be exercised not only more or less – push harder, or resist less – but with ones for which the strength of effort is quantifiable, and for which, in certain very special circumstances, the exact results of the effort may be predictable. (Cartwright, 1999, pp. 66-67)

At this point, Cartwright seems to settle on the contention that at least some properties, including those that physics study, are capacities. Nevertheless, Cartwright (1999) continues to ponder the nature of capacities: “For us, there are properties, and all properties bring capacities with them. (Perhaps, following Sydney Shoemaker, they are all just conglomerates of powers)” (p. 70). If Cartwright (1999) concurs with Shoemaker (1984) concerning capacities or causal powers, then (causal) capacities or (causal) properties can be explained in terms of causal powers.²⁹

As noted, Cartwright does not endorse the law-first view. Capacities do not need laws; rather capacities give rise to causal laws when circumstances are right.

²⁸Qua. (n.d.) In *The Oxford English Dictionary*. Retrieved from <https://en.oxforddictionaries.com/definition/qua>.

²⁹One likely possibility is that the terms “capacities” and “powers” can be used interchangeably: “Any world with the same properties as ours would *ipso facto* have capacities in it, since what a property empowers an object to do is part of what it is to be that property” (Cartwright, 1989, p. 70).

Now, let us turn to Cartwright's notion of the ontological relation between capacities and laws.

3.6 Capacities and laws: The ontological priority

According to Cartwright (1999), there are laws in virtue of capacities: "It is capacities that are basic, and laws of nature obtain – to the extent that they obtain – on account of the capacities" (p. 49).³⁰ Furthermore, there is no isomorphism between a capacity and a law: "The capacity is associated with a single feature – charge – which can be ascribed to a body for a variety of reasons independent of its display of the capacity described in the related law" (Cartwright 1999, pp. 53-54).³¹

As for the ontological problem of identification, Cartwright (1999) contends that: "What makes true, then, the claim, 'Inversion in a population of atoms has the capacity to produce coherent radiation'? In simple Tarski style, just that: [T]he fact that the inversion has the capacity to produce coherent radiation" (p. 73). Irrespective of laws, there are capacities in nature simpliciter according to Cartwright. The facts about capacities make capacity statements true.

As for the epistemological problem of identification, Cartwright invokes the relation between natures of objects and capacities. Cartwright (1999) writes:

My use of the terms *capacity* and *nature* are closely related. When we ascribe to a feature (like charge) a generic capacity (like the Coulomb capacity) by mentioning some canonical behaviour that systems with this capacity would display in ideal circumstances, then I say that that behaviour is *in the nature* of that feature. Most of my arguments in terms of capacities could have been put in terms of natures. (Cartwright, 1999, pp. 84-85)

³⁰Cartwright does not explicitly provide an analysis of how capacities give rise to laws *ceteris paribus*. She rather provides examples about the issue: "I say that Newton's and Coulomb's principles describe the capacities to be moved and to produce a motion that a charged particle has, in the first case the capacity it has on account of its gravitational mass and in the second, on account of its charge" (Cartwright, 1999, p. 65).

³¹What is more, manifestations of capacities depend on circumstances. That is, a single capacity can manifest different behaviors in different settings such that: "There is no fact of the matter about what a system can do just by virtue of having a given capacity. What it does depends on its setting" (Cartwright, 1999, p. 73).

Then natures are conglomerates of capacities. Nomological statements (i.e., capacity statements) are distinguished from the statements of accidents in the sense that the former are statements of capacity ascriptions “like the Coulomb capacity”, whereas the latter are not. Nevertheless, according to Cartwright (1999), law statements are not universally quantified. Instead of laws, capacities explain scientific phenomena.

Unlike the other accounts of laws that have been explicated in this thesis, Cartwright’s (1989, 1999) account draws a lot of criticism that will be evaluated in the next sub-heading.

3.7 Woes and amendments

First, let us turn to Cartwright’s (1989) argument in which she argues that a capacity provides the ability whereby causal laws, which are grounded in causal possibilities, bring about their effects in all settings.³² Cartwright (1989) seems to make two unwarranted assumptions here: (i) I took an aspirin yesterday morning and it relieved my headache; thus, aspirins have the capacity to relieve headaches. However, asserting that an aspirin relieves headaches due to its peculiar capacity, which was manifested in one case (and only in that case), simply begs the question unless there is a priori assumption that aspirins relieve headaches; and (ii) a capacity consists of the effectiveness of a cause in all cases, but Cartwright (1989) assumes that a single case is sufficient to establish that capacity’s existence. Therefore, Cartwright asks the

³²Cartwright (1989) explains herself as follows: “Causal laws, which are relativized to certain given kinds of situation, can be inferred from the probabilities that obtain in those situations. To infer the stronger claim – what I call a capacity claim – one must suppose that the causal possibilities that are established in that situation continue to obtain in various different kinds of situation” (p. 147).

reader simply to trust her argument by fiat concerning the cogency of capacity ascriptions.³³

Secondly, Cartwright (1989) contends: “I claim that the laws of electromagnetic repulsion and attraction, like the law of gravity, and a host of other laws as well, are laws about enduring tendencies or capacities” (p. 1). In other words, laws simply describe capacities. One problem with Cartwright’s claim is that laws are still paramount in terms of covering capacities whereby, say, given that the net force is calculated, then Newton’s laws of motion can explain how objects behave as they do. Psillos (2008) raises a similar worry. In particular, it is laws that individuate capacities: “Why is it the case that nothing has the power to move faster than light? The absence of a certain capacity might also be the consequence of a natural law” (Psillos, 2008, p. 188). This worry stems from the fact that although Cartwright (1989) asserts that instead of laws, capacities are fundamental, she does not provide a metaphysics of capacities. Thus, capacities as explanatory powers ironically remain unanalyzed.³⁴ Accordingly, Cartwright (1989) fails to show that laws are not included in the fundamental entities of the bottom framework.

Thirdly, the previous problem paves the way for a major worry concerning capacities: Are capacities indispensable after all? Cartwright (2007a) thinks that they are because universal laws cannot replace capacities. Expressly, according to Cartwright (2007a), there are no universal fundamental laws due to the problem of identification. Nonetheless, natures with stable causal capacities should ground the

³³Of course, Cartwright (1989) provides the reader with the examples from path analysis and linear causal modeling methods, thereby she thinks that the causal possibilities grounded in capacities can be reliably measured. However, such an amendment is not strong because neither economists nor medical researchers refer to capacities per se in explaining phenomena.

³⁴Maudlin (1993) likewise contends that: “Surely aspirins can relieve headaches, but are we really helped by saying that aspirins have a capacity to relieve headaches which they carry from situation to situation, a capacity whose relation to aspirins’ properties remains entirely unexplicated?” (p. 602).

regularities in the world for there to be regularities in the first place. Thus, Cartwright (2007a) contends that the problem is solved. On the contrary, there is no empirical justification for capacities. As noted, Cartwright (1989) none the less contends that capacities are reliably measured. But, if a single manifestation is sufficient for the existence of a capacity, then: “Why ... should we attribute to x [(i.e., a factor)] to bring about y [(i.e., an effect)], instead of claiming that the occurrence of y was a matter of chance?” (Psillos, 2002, p. 195). As Morrison (1995) points out, we do not gain anything by asserting that aspirins have the capacity to relieve headaches instead of asserting that it is a law that aspirins relieve headaches.³⁵

Moreover, Cartwright (1989, 1999) admits that objects carry capacities even if they are not manifested. How is that possible? Cartwright (1989, 1999) does not provide an explanation. Rather, Cartwright (1989, pp. 167-70) asserts that the standard empiricist notion of experience is incomplete, and our experience of scientific practice shows that causal powers are indispensable elements of explanation. Empiricists would simply raise objections to this claim by appealing to the epistemological grounds and to the problem of underdetermination. In particular, as for the former, there is no apparent way to know about real and single causal laws in the world. That is, even if there were no capacities in the world, we would experience the same sequences of event-types. As for the latter, it is highly unlikely to determine whether capacities explain. Indeed, it is likely to be the case that aspirins relieve headaches because, instead of capacities, there are regular associations between occurrent properties. Thus, Cartwright’s argument regarding

³⁵Nevertheless, Cartwright’s move from single causal possibilities to causal laws, and then to capacities, is unwarranted, as is discussed in the beginning of sub-heading 3.3 of this thesis.

capacities does not only fail to solve the problem of identification, but it is also subjected to the problem of inference – as is faced by the nomic necessitarians.

Fourth, Cartwright (1989) makes an analogy between her argument concerning the reality and the indispensability of capacities, and Sellars's (1963) argument concerning why unobservable entities are needed for explanatory reasons. Psillos (2008) rightly observes that the analogy is weak. Specifically, despite being unobservable, electrons, which can be "identified independently of the entities in the bottom framework" are needed due to their role in terms of bonding of individual atoms together, thereby observable entities can interact in various reactions under different forms, which are observable (Psillos, 2008, p. 182). Thus, Sellars (1963) contends that such unobservable phenomena are needed.

However, the identification of capacities is hitherto a vexing issue. In contrast to Cartwright's (1989) argument, capacities need laws for identification.³⁶ Nonetheless, if capacities are real, laws are prior to capacities in order to "(i) identify them; (ii) connect them with their manifestations; (iii) explain their stability; (iv) explain why some (but not others) obstruct the manifestation of others" (Psillos 2008, p. 191). Cartwright (2008, pp. 195-96) replies to Psillos's (2008) worries. As for the problem of identification, Cartwright (2008) contends:

If an object of mass m manifests its capacity to attract an object of mass M a distance r away and nothing interferes, the second object will have an acceleration Gm/r^2 . Notice that in this ... case we also claim about what behaviour occurs when the capacity is manifested. I can thus mimic Psillos: A given capacity is what it is because of the laws it participates in. These laws often involve reference to other capacities. (Cartwright, 2008, p. 195)

³⁶Psillos (2008) contends that the Humean laws are needed in order to individuate capacities as follows: "Capacities might well be posited, but only after there has been a regular association between relevant event types. No one would mind ascribing to aspirin the capacity to relieve headaches, if that was the product (and indeed it is) of a regular association between taking aspirins and headaches going away" (p. 182). See Psillos (2008, pp. 186-91) about other specific problems concerning the nature of capacities.

What difference do capacities make after all? A world without capacities would not differ from a world with capacities. More importantly, in terms of Ockham's razor, a world with laws is more parsimonious than a world with laws and capacities. Once again, instead of giving a conceptual analysis of capacities, Cartwright (2008) merely talks about what capacities do, e.g., attracting. Instead of replying to Psillos (2008), Cartwright (2008) rephrases his worry. Cartwright must provide a metaphysics of capacities, but she refuses to provide one.

As for the connection of capacities with their manifestations, Cartwright (2008) replies that "the manifestation – 'attracting' – is fixed even if the behaviour described in occurrent-property language – 'acceleration Y ' – is highly various" (p. 195). Thus, a stable capacity is independent of its manifestations. Cartwright (2008) adds that in referring to manifestations, she uses "'tries to X ' where X is the canonical behaviour associated with the capacity" (p. 197). Instead of clarifying, Cartwright (2008) worsens Psillos's (2008) worry. What does it mean for an object to "try to X "? Is it about the nature of that object? If it is, then it will be a worry because Cartwright's (1989, 1999) arguments on the relation between natures and capacities are puzzling. Specifically, Cartwright (1999) initially asserts that "what a property empowers an object to do is part of what it is to be that property" (p. 70). But, Cartwright (1999) later argues that the nature of charge is not indicative of the essence of charge. Then it seems that, according to Cartwright (1999), we have different categories of entities: (i) essences, (ii) natures and (iii) capacities.

How do they differ from one another? Whatever they are in the end, their relations to one another are obscure. Due to this obscurity, Cartwright's (2008) amendment of "tries to X " seems simply to be a linguistic preference to talk about a behavior metaphorically – and nothing more. Hence, Cartwright fails to show what

capacities are after all. Once again, a metaphysical analysis of capacities is needed in order to establish that how having a certain property endows an object with related capacities.³⁷

As for the problems of the stability and the measurement of capacities, Cartwright (2008) responds thusly:

[Capacities] are like forces in that respect. But that does not mean that we can tell by those measurements that what we measure is a capacity. Again, that is like forces. We can measure the acceleration of an object and its mass and multiply the measure the force on it. That does not tell us that there are forces in nature. (Cartwright, 2008, p. 196)

Unlike capacities, we can measure forces by the method of vector addition.

Moreover, as for the method of vector addition, it is a given that there are lawlike principles in the first place whereby vector additions are possible. Are capacities measured through the method of vector addition? If they are also measured through that method, then not only laws do not ground capacities, but also capacities are otiose since their roles are hitherto shouldered by laws alone. Furthermore, if capacities can be added vectorially whereby they can interact, it will be unlikely for capacities to remain stable (cf. Cartwright, 1989, p. 163). If the stability is grounded in capacities' nature, then the aforementioned problems concerning Cartwright's notion of nature emerge. The most Cartwright can show is that "capacities" is just a metaphorical manner of speaking. All in all, Cartwright (2008) shies away from answering Psillos's (2008) questions by abstaining to offer a metaphysics.

³⁷As noted, Cartwright's (1999) talk of what natures and capacities are problematic. Cartwright (1999, p. 82) first contends that there are capacities and natures. Moreover, it is likely that properties are just conglomerates of capacities and objects are composed of properties (Cartwright, 1999, p. 70). It is not clear whether objects with natures are collections of properties, capacities, or properties with capacities. In a more puzzling manner, Cartwright (1989, p. 9) previously asserts that capacities are occurrent properties. If capacities are occurrent properties, then they are not causal powers after all. Nevertheless, one central problem is that if objects are conglomerates of properties that are conglomerates of capacities, then objects are mere bundles of capacities. It is highly counterintuitive that objects are mere causal powers.

The fifth problem is that if laws hold *ceteris paribus*, then lawlike statements would be either false or vacuous. Expressly, “ $F = ma$ ” will be false if at least one of the factors in a system is not held constant. In physical systems, it is almost always the case that there are factors that are not equal. On the other hand, lawlike statements will be vacuous if all factors are taken into account. Specifically, although it is highly unlikely, if all factors are considered, then such statements will be of the form: “All *As* are *Bs*, unless they are not.” Then lawlike statements will be vacuously true. Cartwright may contend that the *ceteris paribus* clause does ascribe only to capacity claims. For instance, according to Cartwright (1999), when the Coulomb’s capacity ascribes, all like charges have the capacity to repel each other, as well as all alike charges have the capacity to attract each other (i.e., “*Ceteris paribus*, all like charges repel and all alike charges attract each other.”) Cartwright’s (2008) reply is not strong unless she gives a criterion of how to individuate capacities, how to connect capacities with their manifestations and so on (i.e., once again, a metaphysics of capacities is needed.)

Overall, Cartwright’s argument that laws are *ceteris paribus* seems to be rhetorical. One reason is that, according to Cartwright (1989, 1999), entities enter into causal interactions with each other because of their stable causal capacities. Thus, stable capacities give rise to causal laws, thereby we observe regularities in nature. However, stability means universality.

Put differently, capacity or law statements are universally quantified.³⁸

Ironically, it seems that Cartwright’s anti-fundamentalism and limited-realism seems

³⁸Cartwright (1999) contends that capacities “try to behave in new arrangements as they have behaved in others” (p. 83).

to backfire, i.e., Cartwright is a fundamentalist and superrealist concerning capacities and capacity claims (cf. Psillos, 2008, pp. 190-91).³⁹

3.8 A prolegomenon to a metaphysics of capacities

According to *The Oxford English Dictionary*, “capacity” is “the ability or power to do or understand something” (*The Oxford English Dictionary*, n.d.).⁴⁰ As noted, Cartwright’s notion of capacity is rather vague. Nonetheless, it is likely that, according to Cartwright (1989, 1999), capacities are causal powers. Let’s say that when we utter that salt dissolves in water, we refer to the capacity of salt to dissolve in water. If what we refer to is salt’s chemical structure, then it is counterintuitive to argue that salt “tries to” dissolve in water because of its chemical structure. Indeed, salt has a stable molecular structure, but molecular structures are not causal powers per se. Or, are they?

In order to improve our understanding of Cartwright’s notion of capacities, we can categorically differentiate between categorical and dispositional properties. Philosophers often argue that Humean metaphysics requires a robust distinction between categorical and dispositional properties (cf. Ellis, 2001, p. 45). Specifically, Humeans hold that there is only logical necessity, whereas non-Humeans, such as Cartwright (1999), think otherwise. As noted, in order to make sense of the idea of a non-logical necessity, philosophers, including Swoyer (1982), Ellis and Lierse

³⁹After I will try to present a new metaphysics of Cartwright’s notion of capacities in the fourth chapter of this thesis, I will consider how to make sense of the *ceteris paribus* clause in the dispositional essentialist framework.

⁴⁰Capacity. (n.d.) In *The Oxford English Dictionary*. Retrieved from <https://en.oxforddictionaries.com/definition/capacity>.

(1994), Ellis (2001, 2009) and Molnar (1999), contend that at least some properties are inherently dispositional.⁴¹

Dispositionalists go one step further: All or all sparse properties are dispositional (cf. Harré & Madden, 1975; Shoemaker 1980, 1984; Mumford 1998, 2004; Bird 2007; Chakravartty 2007). Hence, dispositionalists contend that all properties have causal powers. In other words, properties are simply constituted of their causal roles. Categoricalists is on the other end of the spectrum: All properties are categorical (cf. Lewis, 1986; Armstrong, 1997b). The central impetus behind the distinction between dispositionalists and categoricalists is that dispositionalists, unlike categoricalists, contend that properties' essence grounds how their instances are disposed to behave in regard to certain stimulus conditions. That is, according to dispositionalists, when a property is instantiated, its fixed set of dispositions necessarily follows. Worlds with the same properties have the same natures, which in turn have the same laws. Correspondingly, if dispositional essences ground laws, then laws will be metaphysically necessary.

If Cartwright individuates properties by capacities or stable causal powers, then she should hold that laws are, in some non-logical sense, necessary. Indeed, Cartwright (1999) seems to do accordingly:

[S]o, 'How does the Hume world differ from ours?' It would not differ. Any world with the same properties as ours would *ipso facto* have capacities in it, since what a property empowers an object to do is part of what it is to be that property. (Cartwright, 1999, p. 70)

Hence, Cartwright (1999) would contend that worlds with the same properties would have the same natures, which in turn would necessitate that the worlds would have

⁴¹At the opposite side, there are Humeans, including Lewis (1986), who contend that there is no non-logical necessity in the world, just a "vast mosaic of local matters of particular fact", and there is "no difference without difference in the arrangement of qualities" (pp. ix-x). Thus, according to Humeans, properties themselves are not causally efficacious.

the same causal laws. Then there is a chance that Cartwright's (1989, 1999) view can be on par with that of dispositional essentialists – especially of Chakravartty (2003, 2007). Are capacities and dispositions categorically different? Cartwright seems to be puzzled concerning this issue. In the next chapter, I will try to combine Cartwright's capacities with conventional and multi-track dispositions, and, like Bird (2007), I will try to give a dispositionalist account of laws. Note that even if capacities are combined with dispositions, unless a cogent conceptual analysis of dispositions is given, then Cartwright's new metaphysics of capacities will also face the problems that Ellis (2000, 2001, 2009) has faced previously.

CHAPTER 4

A NEW METAPHYSICS FOR CARTWRIGHT'S ACCOUNT

Capacities are in need of conceptual analysis. Indeed, Mackie (1977) and Earman (1984) ponder the nature of capacities and dispositions. Expressly, Mackie (1977, pp. 365-66) contends that if the talk about capacities is taken seriously, as is taken by Cartwright (1989, 1999), then there are two stances to take concerning the ontological status of capacities: (i) realist and (ii) rationalist stances.⁴²

As for the realist stance, capacities can be regarded as dispositions that are grounded in categorical properties (e.g., chemical structures) of objects. In other words, there are dispositions or capacities if and only if there are categorical bases of objects. When a force is applied on an object, that object is bent because it manifests its capacity to be bent due to its molecular structure. Then the talk of capacities is simply a substitute for the talk of undiscovered categorical properties. In particular, when sciences fully discover chemical structures of objects that can interact in accordance with laws, the talk of dispositions, which hitherto helps to explain behaviors of objects, will become otiose, i.e., categorical properties and laws will explain regularities by themselves alone. This stance is similar to those of categoricalists.

As for the rationalist stance, capacities are regarded as real and inherent properties of objects “whose essential nature it is to tend towards the corresponding manifestation” (Mackie, 1977, p. 366). For example, when an object is bent, it is because that object has an inherent property, capacity or disposition, which is

⁴²Concerning these stances, Mackie (1977) adds that the former is naïve, and the latter is deeply problematic. We will evaluate the related problems (and more) after Cartwright's new metaphysics is given.

ontologically distinct from its categorical base, that is manifested whereby the object is bent. This stance is similar to those of dispositionalists and some dispositional essentialists.

4.1 Making capacities indispensable

Which stance is the most suitable one for Cartwright to take in terms of her notion of capacities? It seems that Cartwright would choose the rationalist stance. There are several reasons for this. Psillos (2002) gives one of them: “Understood in the ‘realist’ way, capacities and the cognate do not hold ... ‘non-Humean powers’” (p. 197). In other words, if Cartwright were a realist, then she would not hold that “[w]hat makes capacity claims true are facts about capacities” (Psillos, 2002, p. 194). Nonetheless, Cartwright (1999) holds that idea. According to the realist stance, capacities as irreducible ontological kinds that are distinct from their categorical bases are not actually possessed by objects. Specifically, if there are facts, then those facts will only be about the regularities between categorical properties of objects after all.

In light of these considerations, there are several views concerning the nature of Cartwright’s capacities. Among these views, Psillos’s (2008) and Price’s (1991) are of the plausible ones. In particular, following Cartwright (1999, p. 70), Psillos (2008) contends that: “[I]t seems that [Cartwright] aligns herself with Shoemaker’s view of properties” (p. 187).

Shoemaker (1980) can be deemed as a dispositionalist since he regards all properties as causal powers essentially. Since Cartwright (1999) seems to reject the empiricist metaphysics, she should replace it with a principled metaphysics of her own. Price (1991) comes to her assistance at this point:

There is one alternative that to my mind would sit easily with Cartwright’s position, an option that also owes much to Hume. It is the kind of pragmatism

of which F. P. Ramsey was the leading modern exponent. Ramsey's (later) account of laws represents them as principles on which we rely in dealing with new cases. This is a position not far on the side from Hume's account of the idea of causal links as grounded in expectations, or on the other from a pragmatic account of the notion of a capacity. (Price, 1991, p. 606)

Specifically, according to "Ramsey's (later) account of laws", laws are heuristic principles and laws would, if known, be used to reinforce predictions, e.g., I will die if I do not drink water; hence, I will drink water. Neither Psillos (2008) nor Price (1991) furthers their elaboration concerning a metaphysics for Cartwright's account. Moreover, contrary to Price (1991), Cartwright's appeal to capacities is independent of pragmatic concerns, i.e., capacities are robustly ontological. An in-depth principled explication of Cartwright's notion of capacities can clarify our understanding of laws. Now, let us turn to a new metaphysics regarding Cartwright's account whereby capacities can be indispensable in terms of explaining laws.

4.2 Capacities are dispositions after all

Cartwright (1989, 1999) intentionally employs the term "capacity" instead of the term "disposition". Is there really a difference between the two? First, following Psillos (2002), this thesis turns to Cartwright's (1999) characterization of capacities. In particular, the features of capacities are as follows:

- Capacities are not restricted to any single kind of manifestation [(Cartwright, 1999, p. 59)].
- They are not to be identified with any particular manifestations [(Cartwright, 1999, p. 64)].
- They have endless manifestations of endless different varieties [(Cartwright, 1999, p. 64)].
- They are highly generic: [T]hey issue in a variety of different kinds of behaviour [(Cartwright, 1999, p. 54)].
- They can be exercised more or less [(Cartwright, 1999, p. 67)].
- They can combine with other capacities [(Cartwright, 1999, p. 54)].
- They can be impeded by other capacities [(Cartwright, 1999, p. 71)].
- They are open-ended [(Cartwright, 1999, p. 59)].

- What makes capacity claims true are facts about capacities [(Cartwright, 1999, p. 72)]. (Psillos, 2002, pp. 193-94)⁴³

Indeed, Psillos (2002) gives us a blueprint concerning a conceptual analysis of Cartwright's notion of capacities. So far so good. At this point, it is an imperative to construct a new metaphysics of capacities by following the blueprint. At first, Cartwright (2007b) contends that capacities are eventually dispositions: "[M]y aim is to understand why I and others should have assimilated [capacities] to dispositions" (p. 196). After listing her "promising candidates for what is special about dispositions", Cartwright (2007b) opines that malleability is the feature that capacities and dispositions share (p. 195).⁴⁴ In particular, capacities and dispositions are alike thereupon:

[Capacities and dispositions] can all be interfered with, and when they are interfered with, there is no guarantee that the canonical manifestations will occur. What does occur, if anything at all, will depend on the type and method of interference and there may be no system to either the possible interferences or the possible affect they have on the capacity's manifestations. (Cartwright, 2007b, p. 201)

Then it seems that Cartwright (2007b) augments the force of Psillos's (2002, p. 193) argument concerning the nature of capacities: There is no isomorphism between a capacity and its manifestation. More importantly, Cartwright (2007b) deems dispositions to be akin to capacities in that respect. What is more, Cartwright (2007b) adds that capacities and dispositions also share the same "threefold distinction" such that: "There is (i) the disposition [or capacity], (ii) the property in virtue of which the system has the disposition [or capacity] and (iii) the underlying structure that ensures that that property is associated with that disposition [or capacity]" (p. 203). Here,

⁴³See Psillos (2002, pp. 193-94).

⁴⁴Cartwright (2007b) defines and evaluates *malleability* as follows: "The central feature that locates capacities in the family of dispositions, I claim, is not conditionality but malleability. All other members of the family of dispositions, habits and character traits seem to have at least one of the three central features of malleability I mentioned: They need triggering, they can be enhanced or they may produce different manifestations, or no manifestation at all, if they are interfered with" (p. 201).

Cartwright (2007b) seems to have her three distinct ontological components in mind: (i) capacities, (ii) properties and (iii) natures. As noted, Cartwright's explication of these three kinds is quite indeterminate.⁴⁵

It is now clear that Cartwright supports not only dispositional essentialist account of properties, but also the dispositionalist view, i.e., all properties have dispositional essences. In other words, according to Cartwright (1999), the properties that sciences study are causally efficacious in virtue of their capacities. Indeed, Cartwright (1999) explicitly states that: "For us, there are properties, and all properties bring capacities with them. (Perhaps, following Sydney Shoemaker, [properties] are all *just* [emphasis added] conglomerates of powers" (p. 70).⁴⁶

4.3 Analyzing dispositions

Prominent dispositionalists include Bird (2007), Mumford (1998, 2004, 2011) and Chakravartty (2013a). All three philosophers (and Cartwright) agree that a disposition is a "causal concept par excellence" (Chakravartty, 2013a, p. 119). First, let us turn to Bird's (2007) analysis of dispositions.

4.3.1 Bird's conditional analysis: Saving Cartwright's capacities

Bird (2007, p. 45) considers himself a dispositional monist (DM): All natural and fundamental properties, which are universals, possess dispositional essences. By "natural", Bird (2007) refers to sparse properties; and by "fundamental", Bird (2007) refers to those properties that sciences (especially physics) investigate. Paradigmatic

⁴⁵Even at times, Cartwright (1999) employs the terms "capacities", "properties" and "natures" interchangeably.

⁴⁶Once again, Cartwright's use of "properties", "capacities" and "natures" is highly obscure whereby her account can be combined with a dispositionalist theory. As noted, she wants to do that, but she is none the less against the idea of thick metaphysical grounding.

examples of dispositions include fragility and solubility. For instance, to have a negative electric charge is merely to possess the disposition or causal power to attract positively charged bodies and to repel the negatively charged ones.

In particular, Bird (2007) contends that dispositions are causal powers that exhibit certain behaviors under certain stimulus conditions.⁴⁷ Correspondently, the link between stimulus conditions and manifestations of dispositions is characterized by subjunctive conditionals because the nature of fundamental and natural properties requires a certain conditional link between such properties' manifestations and stimulus conditions. Bird's (2007) key idea is that if an object possesses a natural and fundamental property, it is necessary that if that property pairs with its related stimulus condition (or property), then the related manifestation will occur. The main impetus behind Bird's notion of disposition is the conditional analysis (CA). Bird (2007) explicates the analysis as follows: "x is disposed to manifest M in response to stimulus S iff [sic] were x to undergo S x would yield manifestation M" (p. 24).

What is more, Bird (2007) re-symbolizes the CA thereupon:

Let ' $D_{(S,M)}x$ ' abbreviate 'x is disposed to manifest M in response to stimulus S, and ' $\rightarrow$ ' symbolize the subjunctive/counterfactual conditional, so that ' $Sx \square \rightarrow Mx$ ' abbreviates 'if x were S it would be M'. Then the (simple) conditional analysis of dispositions may be symbolized:
 (CA) $D_{(S,M)}x \leftrightarrow Sx \square \rightarrow Mx$. (Bird, 2007, p. 24)

As noted, Bird's (2007) key idea suggests that if the simple conditional analysis (SPA) is true, then it is necessarily or "analytically" true:

(CA $\square$) $\square(D_{(S,M)}x \leftrightarrow Sx \square \rightarrow Mx)$ (p. 43).

After giving the nature of dispositions by the CA, Bird (2007) strives to explicate the relationship between properties and their dispositional essences as follows:

⁴⁷Bird (2007) presents his version of DE thusly: "The essential nature of a property is given by its relations with other properties. It wouldn't [sic] be that property unless it engaged in those relations. Consequently, those relations cannot fail to hold (except by the absence of the properties altogether, if that is possible). The laws of nature are thus metaphysically necessary" (p. 2).

[Properties with dispositional essences] are *real* essences, which is to say they concern the nature of the property in question and are not merely reflections of the meanings of the corresponding terms. Thus, according to dispositional essentialism, the real essence of some potency [or property] P includes a disposition to give some particular characteristic manifestation M in response to a characteristic stimulus S. Hence, in all possible worlds, any object that possesses P is disposed to yield M in response to S:
 (DE_p) $\Box(Px \rightarrow D_{(S,M)}x)$. (Bird, 2007, p. 45)⁴⁸

As for laws, according to Bird (2007), from the CA_□ and the DE_p, it follows that:

$$(V) \quad \forall x((Px \ \& \ Sx) \rightarrow Mx) \text{ (p. 46).}$$

Furthermore, this conclusion (V), which concerns a universal generalization, is the “core of the dispositional essentialist explanation of laws” (Bird, 2007, p. 46). Later, in order to augment the force of his account of laws, i.e., in order to amend CA_□ due to the possibility of finkish dispositions and antidotes (Lewis, 1997), Bird (2007) inserts the ceteris paribus clause into his symbolization: “ $\forall x(ceteris \ paribus((Dx \ \& \ Sx) \rightarrow Mx))$ ” (p. 60).⁴⁹ Then it seems that after Bird (2007) gives his ceteris paribus symbolization of laws, his dispositional essentialism can account for both strict and ceteris paribus laws. Nevertheless, it is paradoxical that although Bird (2007) deems laws to be metaphysically necessary, laws are, in some instances, not strict (cf. Chakravartty, 2009; Corry, 2011).

Can we combine Cartwright’s account of capacities and her related account of laws with Bird’s (2007) DM account? It is unlikely that we can. The main reason concerns Cartwright’s (2007b) criterion of malleability that both capacities and dispositions share. In particular, Cartwright (1999) contends that a capacity, which is

⁴⁸Concerning the grounding relation between dispositional properties and laws, Bird (2007) previously contends: “If properties have a dispositional essence then certain relations will hold necessity between the relevant universals; these relations we may identify with the laws of nature. The necessity here is metaphysical” (p. 43).

⁴⁹Bird’s (2007) second version of the symbolization is as follows: “ $\forall x(\text{finks and antidotes to } D \text{ are absent} \rightarrow ((Px \ \& \ Sx) \rightarrow Mx))$ ” (p. 60). Although the thesis deliberately omits his derivation, Bird (2007, p. 60) derives the second version from (CA_→) and (DE_p). He offers this particular symbolization in order to amend his argument in the face of criticisms by Lewis (1997) regarding finkish dispositions and antidotes. The inquiring reader may see Bird (1998, 2007) and Lewis (1997) in order to further her understanding concerning the related debate.

“deployed in the models we construct in the exact sciences”, is “associated with a specific feature ... which can be ascribed to a body for a variety of reasons independent of its display of the capacity described in the related law” (pp. 53-54).

Regarding theory formation in exact sciences, Cartwright (1999) concludes thusly:

We must develop on the one hand *concepts* (like ‘the force due to gravity’, ‘the force due to charge’, or ‘capacitance’, ‘resistance’, ‘impedance’ ...) and on the other, *rules for combination*; and what we assume about each constrains the other, for in the end the two must work together in a regular way. When the concepts are instantiated in the arrangements covered by the rules, the rules must tell us what happens, where *regularity* is built into the demand for a rule, *whenever* the arrangement is thus-and-thus so, what happens is what the rule says should happen. (Cartwright, 1999, p. 56)

According to Cartwright (1999), that is how causal laws as stable capacities emerge. Explicitly, there are laboratory conditions and models, on the one hand, under which stable capacities result in regularities. On the other hand, there are non-laboratory, real-world conditions in which we observe the similar regularities. One likely reason behind such similarities is that the objects in laboratory conditions have (or are) the same capacities or dispositional properties with the objects in real-world conditions.

However, say, the Coulomb’s capacity does not always result in its canonical behavior in non-laboratory situations as it generally does in laboratory ones, e.g., sometimes electrons do not move in opposite directions from each other. Then according to Cartwright (1999), this shows that the very same disposition or capacity can generate various different behaviors in different conditions with respect to relevant nomological machines.⁵⁰ Cartwright (1999) explicitly states that:

“Disposition terms, *as they are usually understood* [emphasis added], are tied one-to-one to law-like [*sic*] regularities. But capacities, as I use the term, are not restricted to

⁵⁰Notwithstanding, one central thesis of Cartwright (1999) is that: “Our most wide-ranging scientific knowledge is not knowledge of laws but knowledge of the *natures* of things, knowledge that allows us to build new nomological machines never before seen giving rise to new laws never before dreamt of” (p. 4).

any single kind of manifestation. Objects with a given capacity can behave very differently in different circumstances” (p. 59).⁵¹ As noted, Cartwright’s (2007b) understanding of “disposition” is quite different from that of Bird (2007).

Specifically, according to Cartwright (2007b), dispositions, in the standard sense, are not variable. Bird’s (2007) conditional analysis of dispositions, which is grounded in the CA, shows this very point: A (conventional) disposition corresponds to a single pair of stimulus condition and manifestation. Unless Cartwright and Bird reach a consensus concerning the malleability of dispositions, Cartwright’s account of capacities cannot be combined with Bird’s account of dispositions. Now, let us turn to Mumford’s (1998) analysis of dispositions.

4.3.2 Mumford’s entailment analysis and his functionalist theory

Can Mumford’s (1998) account be of any help to Cartwright? It seems not to be the case. Foremost, according to Mumford (Mumford & Anjum, 2011): (i) dispositions are real (Mumford & Anjum, 2011, p. 4); (ii) dispositions are perceived in proprioception (Mumford & Anjum, 2011, pp. 207-09); (iii) dispositions are causally efficacious, i.e., causal powers (Mumford & Anjum, 2011, p. 2); and (iv) all properties are just conglomerates of causal powers (Mumford & Anjum, 2011, p. 16).⁵² Moreover, according to Mumford (as cited in Hawthorne & Manley, 2005), dispositional properties differ from categorical ones in the sense that a “certain kind of counterfactual is a priori entailed by the former” (p. 180) thereupon:

P is a dispositional property if and only if *P* entailed certain conditionals as a matter of conceptual necessity. Now, given that all properties have causal

⁵¹Cartwright (1999) further adds that: “There is no fact of the matter about what *occurs* when charges interact. With the right kind of structure we can get virtually any motion at all. We can even create environments in which the Coulomb *repulsion* between two negatively charged particles *causes them to move closer together*” (p. 59).

⁵²In his earlier work, Mumford contends that the causal roles of (dispositional) properties are determined by those properties’ instances (Mumford, 1998, p. 161).

roles, whether any property *P* is to be construed as a dispositional property or not is a matter relative to a particular causal role. If a causal role is one that *P* occupies as a matter of conceptual necessity, then *P* is dispositional relative to that causal role; if it doesn't occupy that causal role as a matter of conceptual necessity but does so as a matter of fact, then it is non-dispositional relative to that causal role. (Mumford, 1998, p. 215)⁵³

Indeed, Mumford's (1998) entailment analysis is different from Bird's (2007)

conditional analysis whereby, unlike the latter, the former argues that the

"connection between dispositions and conditionals is indirect and mediated by the

functional roles that we ascribe when we ascribe dispositions" (Mumford, 1998, p.

66). Thus, Mumford (1998) contends that no conditional analysis is sufficient to

establish that there are real dispositions besides categorical properties as follows:

What I suggest is the rejection of a solely conditional analysis of dispositions and that we treat them as real instantiations of properties which afford possibilities rather than just being shorthand ways of talking about certain combinations of events. The alternative view to the empiricist conditional analysis view is thus one of dispositions as instantiated properties. (Mumford, 1998, p. 63)⁵⁴

As noted, according to Mumford (1998), all properties have dispositional essences

through the means of "a functionalist theory of dispositions where the dispositional

and the non-dispositional are understood as two distinct ways of denoting the very

same instantiations of properties" (p. 23).⁵⁵ Specifically, Mumford (1998) contends

that dispositions are not second-order properties and property dualism is an

⁵³Accordingly, see Mumford (1998) concerning Mumford's argument for the categorical and dispositional distinction. Mumford's version is not one of those of the standard conditional analysis of dispositions. Specifically, Mumford (1998) contends that the "relation between disposition ascriptions and true conditional statements is not one of equivalence, which would permit the reduction of dispositions to complexes of events named in the antecedents and consequents of those conditionals" (p. 66).

⁵⁴Concerning his notion of dispositions, Mumford (1998) subsequently argues that: "The concept of a disposition is a concept of something that lies behind what occurs and what is verifiable. We accept the possibility of particulars possessing dispositions which they never manifest and we accept the possibility of kinds possessing dispositions though no kind-member has manifested them" (p. 63).

⁵⁵Mumford's (1998) functionalist theory of dispositions is summarized as follows: "[N]ature consists of hierarchically ordered levels where at each level there are entities or properties that can be characterized either dispositionally or structurally and whether they are dispositional or structural characterizations depends on their explanatory relations to other entities or properties within the whole of which they are part" (pp. 214-15).

illusion.⁵⁶ Mumford's (1998) one central thesis is that the identification of dispositions should be token-token, not type-type (cf. Lewis, 1972):

A disposition ascription is a functional characterization of a property. It is to say what causal contributions the possession of that property makes to its owner without saying anything about how the causal role is brought about. These causal roles are actually occupied by categorical bases but we cannot straightforwardly reduce dispositions to such bases. The identities between bases and dispositions is not an analytic matter. (Mumford, 1998, p. 207)

That is to say, according to Mumford (1998), a dispositional predicate's function is to attribute its characteristic property that executes its characteristic causal role "as a matter of conceptual necessity" (pp. 75-76).⁵⁷

As for laws, like Ellis (2001) and Bird (2007), Mumford (1998) argues that given that there are laws, their sole role will merely be describing the dispositional essences of properties. However, unlike Ellis (2001) and Bird (2007), Mumford (1998) contends that there is no need for laws in our ontology: "[W]e replace laws of nature with real dispositions as the ultimate, inexplicable units which are the explanations of change" (p. 228). Mumford (1998) subsequently elucidates his idea: "[L]aws, *qua* true generalities, if they exist at all, are ontologically parasitic upon the capacities of particulars, rather than the other way around" (p. 230). As one may infer, Mumford (1998) is a dispositional essentialist: "Basically, an electron is an electron solely in virtue of its dispositions to behave; hence anything that was not disposed to behave in this kind of way would not be an electron but some other kind of subatomic entity" (p. 234).⁵⁸ In his later work, Mumford (2004) argues that dispositions render laws otiose and the talk of laws is merely symbolic nevertheless.

⁵⁶Mumford (1998) rightly presents property dualism thusly: "The dualist claim is that there are distinct dispositional and categorical properties inhabiting the world in the same way that dualists in respect of other types of property may argue that there are distinct mental and physical properties or distinct temporal and non-temporal properties" (p. 95).

⁵⁷Mumford's (1998) formulation of dispositional properties is that: "[*d*] is a dispositional property iff [*sic*] *d* is a functional property occupying role *by definition*" (p. 198).

⁵⁸Note that unlike Ellis and Lierse (1994), Mumford (1998) argues that laws need not to be metaphysically necessary: "[T]his contentious move [by Ellis and Lierse (1994)] is ... unnecessary"

Can we combine Cartwright's account of capacities and her related account of laws with Mumford's (1998, 2011) dispositional essentialist account (i.e., his functionalist theory)? Although there are some problems, which are similar to those that challenge Bird's (2007) account, that challenge Mumford's (1998, 2011) account, it would be a more likely endeavor compared to the endeavor concerning Bird's (2007) account. In particular, compared to Bird's (2007) analysis, Mumford's (1998) entailment analysis is more suitable to capacities, which are malleable.

Regarding the nature of dispositions, Mumford (1998) contends thusly:

If we accept 'x is elastic', then we must accept a set of conditionals: 'if pulled, then stretches', 'if released, then contracts', 'if pressured, then bends', 'if dropped, then bounces', and so on. Entailment of a set of conditionals makes elasticity, *or any other disposition*, a multiply manifested or 'multi-track' disposition. This form of the orthodox view ... is one to which I will offer support. Such conditional entailment [will be] dependent upon the understanding of dispositions as real properties that support the possibilities that a conditional describes. (Mumford, 1998, pp. 66-67)

One essential virtue concerning Mumford's notion of disposition is that Mumford's dispositions are amenable to Cartwright's account such that a disposition or a capacity does not correspond to a single pair of stimulus condition and manifestation, i.e., Mumford (1998) and Cartwright (1999, 2007b) agree that dispositions and capacities are multi-track. In particular, an electric charge, which is the paragon of capacity according to Cartwright (1999, pp. 59), is a multi-track disposition with various different stimulus conditions: When the Coulomb's capacity is ascribed, in virtue of that capacity, a 100,000 nanocoulombs (nC) charged object being placed at 30 millimeters (mm) away from a 200,000 nC charged object experiences

since "that is in virtue of behaviour B that a particular x is classified within a kind K does not entail that x necessarily has behaviour B" (p. 237). In his later work, Mumford (Mumford & Anjum, 2011) contends that the dispositional modality is *sui generis*. However, Hawthorne and Manley (2005) rightly argues that Mumford (1998) does not directly address the following issue: If dispositions as causal powers are real, then it will not be clear in which aspect laws are not (metaphysically) necessary. See Mumford (1998) concerning Mumford's symbolization of laws.

(approximately) 200 Newton (N) force, whereas when it is placed at 60 mm away from a 400,000 nC charged object, the experienced force is (approximately) 100 N.⁵⁹ Cartwright (1999) sums up her stance concerning capacities thereon: “The point I want to stress is that capacities are not to be identified with *any particular* [emphasis added] manifestations” (p. 64).⁶⁰ Again, it is evident that Cartwright (1999) deems her capacities to be multi-track. Furthermore, similar to Mumford (Mumford & Anjum 2011, p. 5), Cartwright (1999) also considers capacities to be real causal powers, even if they remain unmanifested. Last, Cartwright (1999) considers properties to be conglomerates of causal powers (cf. Mumford & Anjum, 2011, p. 3).

As to woes, although Cartwright (1999) contends, as Mumford (1998) does, that capacities or dispositions are real, Cartwright (1999) does not claim that they are perceived in proprioception (cf. Mumford & Anjum, 2011).⁶¹ Rather, according to Cartwright (1999, pp. 72-73), the brute facts concerning capacity claims make such claims true. That is, Cartwright (1999) argues as follows:

Capacity claims, about charge, say, are made true by facts about what it is in the nature of an object to do by virtue of being charged. To take this stance of course is to make a radical departure from the usual empiricist view about what kind of facts there are. (Cartwright, 1999, p. 72)

Indeed, one plausible inference from the above-mentioned quote is that if “facts about what it is in the nature of an object” do not belong to the “usual empiricist view about what kind of facts there are”, then such facts may be perceived in

⁵⁹Regarding the multi-track nature of capacities or dispositions, we can also give an example that fragility is a multi-track disposition with different stimulus conditions such as “being hammered”, “being stressed”, “being thrown” and so on.

⁶⁰As for the aforementioned electric charge example, Cartwright (1999) concludes that: “Similarly charged particles repel each other, opposite charges attract; what that can amount to in terms of the motions and locations of the particles is limited only by our imagination. Taxes affect prices, but what happens to the prices depends on the economics we build and how well we build them [(i.e., nomological machines)]” (p. 64).

⁶¹According to Mumford (Mumford & Anjum, 2011), proprioception “allows us to get the sense of power acting upon our bodies that we are able to overcome and also power exercised by our bodies that meets with resistance” (p. 209).

proprioception – if proprioception does not belong to “the usual empiricist view.”

Yet either in Cartwright (1989) or in Cartwright (1999), Cartwright does not explicitly adhere to the proprioceptive detection of natures because, probably, proprioception is a conduit for direct experience, i.e., proprioception concerns the usual empiricist view about the kinds of facts.

As noted in the sub-heading 3.3 of this thesis, concerning Cartwright’s account of capacities and Mumford’s account of dispositions, the vector addition of capacities is problematic because there is no one accepted metric to represent capacities vectorially. What is more, capacities will not remain stable if they are added vectorially. Nevertheless, laws will still be prior to capacities if capacities are added vectorially. As noted, this conclusion is rejected by both Cartwright (1989, 1999) and Mumford (1998).

As for the individuation of capacities, Cartwright (1999) contends that: “[T]here is a mere ‘brute-fact connection’ between what charge is and how charged particles behave *qua* being charged” (p. 83). In other words, according to Cartwright (1999), it is a brute fact that a capacity is identified by its nature (cf. Chakravartty, 2003, 2007). However, Mumford (1998, p. 224) argues that dispositions are identified solely by their manifestations, which are properties themselves.

Compared to Bird (2007), Mumford (1998, 2004) comes much closer to Cartwright (1989, 1999, 2007b) in terms of the congruence between their accounts of capacities and dispositions. Nonetheless, Mumford’s (Mumford & Anjum, 2011) later argument concerning his notion of causal powers or dispositions obscures his earlier view concerning his entailment analysis and his functionalist theory of dispositions. Therefore, it is unlikely to combine Cartwright’s and Mumford’s accounts of causal powers in order to provide Cartwright’s account of capacities with

a conceptual analysis. Now, I will try to provide a new metaphysical analysis of Cartwright's account of capacities, first through Chakravartty's (2003) CPIT, and then through combining capacities with multi-track dispositions.⁶²

4.4 A prelude to a new metaphysics for capacities

Why is giving an ability analysis by combining capacities with multi-track dispositions is a promising metaphysics of Cartwright's theory? There are two main reasons behind this contention. One of them is related to the multi-track nature of capacities, and the other is related to the cogency of my ability analysis: (i) as noted, Cartwright (2007b) regards capacities as associated with more than one couple of stimulus condition and manifestation thus, capacities are not conventional dispositions, but the (infinitely) multi-track ones; and (ii) a conditional analysis, such as Bird's (2007), cannot account for the multi-track nature of capacities due to its structural characteristic that links a single disposition with a single conditional.⁶³

Before going further, it is important to note that a simple maneuver could let us explicate capacities essentially as conventional dispositions. Dispositionalists (e.g., Chakravartty (2003, 2007) and Bird (2007)), who think that all or large number

⁶²Note that neither vices nor virtues of Bird's (2007) and Mumford's (1998, 2004) accounts are explicated in the related sub-headings of this thesis. One primary aim of the fourth chapter is to find out whether their notions of causal powers and related analyses of such powers can be conflated with Cartwright's notion of capacities. Thus, the woes and amendments of Bird (2007) and Mumford (1998, 2004) concerning their notions of dispositions, and their analyses of such dispositions, are beyond the scope of this thesis.

⁶³Bird (2007, pp. 21-24) and Ellis and Lierse (1994, p. 29) are among the philosophers who acknowledge that there are irreducibly multi-track dispositions. By leaving the problems of finkish dispositions and antidotes aside, Manley and Wasserman (2008) contends that there are five additional problems that would jeopardize any conditional analysis. A possible amendment for dispositions is to consider them as corresponding to a very large number of conditionals, with each conditional characterizes a "fully specific scenario that settles everything causally relevant to the manifestation of the disposition" (Manley & Wasserman, 2008, p. 72). However, not only it is highly unlikely to reach a "fully specific scenario" in a given situation, but also such settlement could render disposition claims either vacuous or false.

of dispositions are conventional, agree with Cartwright (1989) that causal properties are largely versatile.

That is, although the association between a dispositional property and its capacities or dispositions is fixed, such a property can give rise to a vast array of occurrent behaviors depending on the collection of dispositional or causal properties that are present in the relevant context. However, unlike Bird (2007) and Chakravartty (2003), Cartwright (1989, pp. 190-91) contends that capacities are versatile in the sense that causal properties give rise to distinct dispositions in different situations, i.e., the association between a property and its capacities is variable and context-dependent.

Of course, a negatively charged particle in virtue of its related capacity or disposition, occasionally, does not attract its positively charged counterparts in certain situations. However, it attracts them at other times. Thus, one can claim that the association between the Coulomb's capacity, which seems to be a causal property, and its related disposition (i.e., "disposition to attract") is not invariant because it does vary in some cases.

Such a variance is of epistemological help. Specifically, it is a law that negatively charged particles attract positively charged ones leaving interfering factors aside. If there are such factors at play, then we will know that the Coulomb's capacity is interfered with, i.e., the capacity will not manifest itself as it usually does. Subsequently, such epistemological help can give Cartwright (1989) a chance to insert the *ceteris paribus* clause into the capacity statements: [C]eteris paribus, negatively charged particles attract positively charged ones. At this point, Cartwright (1989) contends as follows:

I hope by now it becomes apparent: [T]he logic that uses what happens in ideal circumstances to explain what happens in real ones is the logic of

tendencies or capacities. What is an ideal situation for studying a particular factor? It is a situation in which all other ‘disturbing’ factors are missing. And what is special about that? *When all other disturbances are absent, the factor manifests its power explicitly in its behaviour* [emphasis added]. When nothing else is going on, you can see what tendencies a factor has by looking at what it does. This tells you something about what will happen in very different, mixed circumstances – but *only if* you assume that the factor has a fixed capacity that it carries with it from situation to situation. (Cartwright, 1989, pp. 190-91)

Ontologically speaking, the set of dispositions a dispositional property has is invariant in all circumstances. Varying manifestations of a capacity or a disposition merely express an epistemological virtue whereby we can differentiate genuine nomological statements from accidents, i.e., it just concerns the epistemological problem of identification of laws. Of course, different stimulus conditions can bring about different manifestations of a property, but only natures, in Cartwright’s terms, do determine the set of dispositions a (dispositional) property can have.

In particular, according to Cartwright (1999, 2007b), although capacities are ontologically stable, none of them is associated with a single pair of stimulus condition and manifestation. Cartwright (1999, 2007b) seems a bit puzzled here concerning her notion of capacities.⁶⁴ One likely reason behind her puzzlement is that Cartwright (2007b) deems the conditional analysis as the sole conceptual tool in explicating dispositions. That is, if dispositions are characterized in terms of conditionals alone, then capacities will not be combined with conventional dispositions because Cartwright (1999, 2007b) surmises that dispositions are analyzable *only* in terms of a single pair of stimulus condition and manifestation. On

⁶⁴As Cartwright (1989, 1999) is previously shown to be puzzled concerning her notions of “natures”, “properties” and “capacities”.

the other hand, capacities can give rise to “endless different manifestations of endless varieties” (Cartwright, 1999, p. 64).⁶⁵

Following Vetter (2013), one alternative formulation of the conditional analysis of dispositions is as follows:

(ST) Where D is a disposition and C a conditional of the form: [I]f x were S, then x would be M, D is adequately characterized by C (and C alone) only if

- (1) For all objects x that have D, if x were S, then *ceteris paribus* x would be M
- (2) For all objects x that have D, if x manifests D at t, then x is M at t and x is S at or before t. (Vetter, 2013, p. 334)

Vetter (2013) adds that: “Hence if D is a single-track disposition, then there is a conditional C that fulfils conditions (1) and (2)” (p. 334). In other words, unless a single conditional by itself identifies “D”, then “D” is a multi-track disposition according to Vetter (2013).

According to Cartwright (1999), massive objects behave regularly under laboratory conditions due, in part, to their possession of the gravitational capacity. Objects sometimes do not behave as they are expected to do in non-laboratory conditions although their capacities remain stable. Thus, according to Cartwright (1999), capacities, in general, manifest differently in different circumstances, i.e., capacities are not conventional in terms of the conditional analysis. However, if we dispense with the conditional analyses in characterizing dispositions, then we will dispense with the stimulus conditions as a factor in identifying dispositions, which in turn might pave the way for the characterization of capacities as conventional dispositions. Notwithstanding, given that the conditional analysis is abandoned, then a plausible novel alternative, which does not adhere to the link between stimulus

⁶⁵Cartwright (1999) explicitly highlights a tendency of dispositionalists in analyzing dispositions in terms of single conditionals: “I talk of *capacities*, which give rise to highly varied behaviours, rather than of *dispositions*, which are usually tied to single manifestations” (p. 64).

conditions and manifestations, in order to individuate dispositions or capacities is required. Indeed, Chakravartty (2003, 2007) gives such an alternative.

Consequently, there are two different options for us in providing a new metaphysics of Cartwright's account of capacities as dispositions or dispositional properties: (i) dispensing with any form of conditional analysis in individuating dispositions and providing an entirely novel alternative in terms of characterizing dispositions; and (ii) combining capacities with multi-track dispositions by giving an ability analysis whereby capacities are individuated not by "any particular manifestations", but by "endless different manifestations of endless varieties" (Cartwright, 1999, p. 64). Now, I will try to evaluate these alternatives in detail, one by one.

4.5 Capacities as dispositions: Chakravartty's CPIT to the rescue

In this sub-heading, we will look at Chakravartty's (2003, 2007) arguments concerning his causal property identity thesis (CPIT), i.e., his version of the dispositional essentialism, and his related account of laws in order to explicate whether his characterization of dispositions or dispositional properties can give a metaphysics of Cartwright's account of capacities.⁶⁶

Following Shoemaker (1980), Chakravartty (2003) contends that there is causal necessity in the world due to real causal properties, which necessarily generalize particular causal relations to causal laws whereby we account for regularities in nature as follows:

The realist claims that particulars possess features in virtue of which they participate in concrete instances of causation, and that these same features may also be present at other times, in other places, and in different particulars, thus generating regularities. These features are causal properties.

⁶⁶Note that Chakravartty (2007, p. 123) later refers to his thesis not as CPIT but as dispositional identity thesis (DIT, henceforth).

Every case of singular causation is an instance of general causation, because singular causal relata incorporate properties that are subsumable under causal laws. (Chakravartty, 2003, pp. 393-94)

In his later work, Chakravartty (2007) highlights his notions of properties and causal laws thusly:

The account of properties I will defend stems from path-breaking work by Sydney Shoemaker, in which he argues that the necessity of causal relations follows from a specific understanding of the nature of causal properties. Once this view is stated, it is immediately clear that the necessity it affords is generalizable. That is, the necessary character of causal phenomena in the context of singular causation immediately yields an account of general causation – an account in terms of laws of nature. (Chakravartty, 2007, p. 121)

Here, Chakravartty's (2003, 2007) understanding concerning causal properties and laws is in line with that of Cartwright (1989, 1999). As noted, according to Cartwright (1999), objects carry stable capacities, causal powers or properties, and the capacity ascriptions guarantee that there are causal laws. Both Chakravartty and Cartwright are causal realists. That is, they think that there is a non-logical necessity and such a necessity can be accounted by causal powers. Thus, Chakravartty's (2003, 2007) idea seems to be on par with that of Cartwright (1999). In particular, objects that carry the same causal properties are "disposed to behave in particular ways in particular circumstances" and "[s]ome of the interactions elicited by these circumstances are experienced by us in the form of detected regularities" (Chakravartty, 2003, p. 394).⁶⁷ This contention is reminiscent that of Cartwright (1999), which is as follows:

It is in the nature of a force to produce an acceleration of the requisite size. That means that, *ceteris paribus*, it will produce that acceleration. But even when other causes at work, it will 'try' to do so. In general, what counts as 'trying' will differ from one kind of cause to another. To ascribe a behaviour

⁶⁷Chakravartty (2007) similarly argues as follows: "The explanation I have presaged thus far is that particulars have properties in virtue of which they participate in causal processes, and these same properties can be present at other times, places, and in different particulars, thus generating regularities. Every case of singular causation is thus an instance of general causation, because singular causal processes incorporate instance of properties that are subsumable under general laws" (p. 122).

to the nature of a feature is to claim that that behaviour is exportable beyond the strict confines of the *ceteris paribus* conditions, although usually only as a ‘tendency’ or a ‘trying’. (Cartwright, 1999, pp. 28-29)

Cartwright’s use of “trying” is akin to Chakravartty’s use of “disposed to behave”:

They both refer to inherent causal powers or dispositions.⁶⁸ Moreover, both Chakravartty (2003) and Cartwright (1999) contend that we observe regularities in nature due to stable causal powers, dispositions or capacities. One reason behind such a similarity can be that both Chakravartty (2003) and Cartwright (1989, 1999) follow Shoemaker (1980) in terms of their understanding of the relation between the properties and the necessity in nature.

Let us look at the three assumptions of Chakravartty (2003) concerning his CPIT in order to better understand his stance. First, laws are not linguistic entities, but “those aspects of nature that *make* the linguistic devices we employ to describe them true or false” (Chakravartty, 2003, p. 394). Thus, Chakravartty is a realist about laws, which are indispensable part of our ontology. As we have already known, Cartwright (1989, 1999) strives to dethrone fundamental laws. On the other hand, Cartwright (2016) acknowledges that causal, phenomenological and *ceteris paribus* laws are of paramount importance in sciences. Replying to Psillos (2008), Cartwright (2008) contends thereupon:

The law claims I don’t like are those that report regular associations among occurrent properties. But there are other “laws” that I endorse wholeheartedly; for instance, “An object of mass m has a capacity of strength GMm/r^2 to attract a mass of size M a distant r away”. This law ascribes a given capacity to a property that we have other ways to identify. Or, “If an object of mass m manifests its capacity to attract an object of mass M a distance r away and nothing interferes, the second object will have an acceleration GMm/r^2 . I can thus mimic Psillos: A given capacity is what it is because of the laws it participates in. (Cartwright, 2008, p. 195)

⁶⁸As noted, Cartwright often employs the terms “natures” and “capacities” interchangeably. By “force”, Cartwright (1999, p. 28) refers to a capacity.

By “occurrent properties”, Cartwright (2008) considers categorical properties, as well as the Humean understanding of laws that report regular associations among such properties. Then she is against the regularity accounts of laws. It is not an unpopular position after all. Nevertheless, all dispositionalists are against such a Humean idea. Cartwright’s (2008, p. 195) example of a law statement in the above-mentioned quote is an instance of a capacity claim, which can be generalizable into a causal law statement. If Cartwright is a fundamentalist concerning capacities, which are stable from situation to situation, then Cartwright is also a fundamentalist concerning capacity claims (i.e., law statements).⁶⁹ What is more, Cartwright (2008, p. 195) admits that laws individuate capacities. However, as noted, she also contends that capacities are prior to laws. Such puzzlements of Cartwright leave the door open for the future studies concerning a metaphysics of Cartwright’s theory. It is plausible to claim that, like Chakravartty (2003, 2007), Cartwright (1999) believes that laws are non-linguistic entities after all.

Second, following Shoemaker (1980), Chakravartty (2003) assumes that: “A causal property may be identified as the property that it is in virtue of its relations to other properties. The conjunction of all causal laws thus specifies the natures of all causal properties” (p. 394).⁷⁰ Chakravartty (2003) refers to this central idea of his as CPIT. Third, unlike Shoemaker (1980), Chakravartty (2003) holds a “realist account of dispositions: [O]ne according to which they are properly viewed as genuine, occurrent properties, regardless of whether any particular behavioural manifestations

⁶⁹Cartwright’s stance regarding capacities and laws can be summed up as follows: Capacities are the properties of objects. Capacities interact with one another necessarily when they are manifested. Such a necessity among capacities gives rise to regularities *ceteris paribus*. I leave it to the reader to decipher in which respect capacities differ from dispositions as causal powers. To me, Cartwright’s distinction between capacities and dispositions is spurious.

⁷⁰Shoemaker (1980) contends that “the identity of a property is completely determined by its *potential* [emphasis added] for contributing to the causal powers of the things that have it” (p. 133).

are realized” (pp. 394-95). These last two assumptions are also in line with Cartwright’s (1989, 1999) general thesis.

Expressly, unlike Bird (2007), Chakravartty (2003, 2007) does not try to identify dispositions by giving a conceptual analysis of them (e.g., a conditional analysis). Rather, Chakravartty (2007) strives to characterize dispositions by claiming that the “identity of a causal property is determined by the dispositions it confers” (p. 126).⁷¹ That is, the nature or essence of a property wholly incorporates its causal functions. A causal function in turn wholly incorporates its total set of causes and effects. Technically, Chakravartty (2007) contends that the causal function of a property is expressed in terms of a Ramsey sentence:

To obtain the Ramsey sentence of a theory one conjoins its axioms, and then replaces all of the unobservable terms with existentially quantified predicate variables. An unobservable entity whose place is held by a variable in a Ramsey sentence is “whatever it is” that satisfies the relations specified by the sentence. This ‘indirect’ reference is achieved by ‘purely logical terms (variables, quantifiers, etc.) plus terms whose *direct* referents are items of acquaintance [i.e. observables]’ (Maxwell, 1970a, p. 16). One does not know what the natures of the unobservable entities are, but one can assert that they exist and stand in certain relations. ‘This ... may be taken as an explication of the claim of Russell and others that our knowledge of the theoretical is limited to its purely structural characteristics and that we are ignorant concerning its intrinsic nature’ (Maxwell, 1970b, p. 188). (Chakravartty, 2007, pp. 37-38)

⁷¹Chakravartty (2007) contends that: “Some think that dispositional-categorical distinction does not apply to properties at all, but merely to the predicates that name them, and that all causal properties are describable either dispositionally or categorically in principle if not in practice. As far as semirealism is concerned, these are open questions, possible answers to which are all consistent with DIT” (p. 124). Contra Chakravartty (2007), these questions are not open. In particular, if a disposition or a dispositional property is simply “grounded in a categorical property” (Chakravartty, 2007, p. 124), then, as Psillos (2002, p. 196) aptly observes, that disposition will merely be a “place-holder for the categorical property which, were it to become known, could explain fully the relevant causal behaviour of the object” (cf. Mackie, 1977, pp. 365-66). Later, Chakravartty (2007) re-evaluates his position: “According to dispositional realism, dispositions are properly viewed as genuine occurrent properties regardless of whether any specific behavioural manifestation occurs. From hereon [*sic*], I will assume a realism about dispositions” (p. 126). In one of his most recent works, Chakravartty (2017, p. 26) employs the terms “dispositions” and “dispositional properties” interchangeably. Nevertheless, according to Chakravartty, *all* properties have dispositional essences. There is more to come on this issue in the fifth chapter of this thesis.

That is, any two Ramsey sentences, whose observable consequences are the same, do not have conflicting consequences in terms of their theoretical commitments. A Ramsey sentence describes the total observable content of a complete and true theory. Following Maxwell (1970a, p. 17), Chakravartty (2007) deems “causal connection” as a structural property whereby “the unobservables interact with one another and with observables and, thus, that Ramsey sentences have observable consequences” (p. 39). According to Chakravartty (2007), only those properties that carry out the same theoretical functions are equivalent. The theoretical functions of a property determine its dispositions: A property empowers its instances with alike dispositions. Thus, all properties have only dispositional essences.

This particular move by Chakravartty (2007) paves the way for his notion of semirealism (i.e., Chakravartty’s (2007) stance of entity realism). Explicitly, Chakravartty (2007) contends that we have knowledge of the concrete structures, which are the “relations among first-order occurrent properties of things” (p. 41), and, as noted, the causal connection is a structural property. At this point, Chakravartty’s (2007) notions of properties, causal powers, dispositions, natures and causation become clear:

The first-order properties whose relations comprise concrete structures are what I will call *causal* properties. They confer dispositions for relations, and thus dispositions for behaviour on the particulars that have them. Why and how do particulars interact? It is in virtue of the fact that they have certain properties that they behave in the ways they do. Properties such as masses, charges, accelerations, volumes, and temperatures, all confer on the objects that have them certain abilities or capacities. These capacities are dispositions to behave in certain ways when in the presence or absence of other particulars and their properties. The property of mass confers, *inter alia*, the disposition of a body to be accelerated under applied forces. It is the ways in which these dispositions are linked to one another – that is, the ways in which particulars with various properties are disposed to act in consort with others – that produce causal activity. Causation, ultimately, has to do with relations determined by dispositions, conferred by causal properties. (Chakravartty, 2007, pp. 41-42)

Chakravartty's (2007) stance hitherto seems highly in line with that of Cartwright (1989, 1999). In particular, they both hold that properties are causally efficacious. Such properties confer dispositions or capacities whereby, leaving interfering factors aside, entities behave as they regularly do. Notwithstanding, Chakravartty's (2003, 2007) characterization of properties, natures and dispositions are more illuminating than that of Cartwright (1989, 1999).

Such a disambiguation in Cartwright's (1989, 1999) argument is a vice and a virtue in the sense that giving a metaphysics of Cartwright's account is relatively not challenging. In order to refresh our memory, it is important to remember that both Chakravartty (2007) and Cartwright (1999) are realists about capacities or dispositions. That is, they are entity realists about singular causal relations, which in turn can give rise to causal laws; and both of them claim that epistemology of science requires real stable causal powers, thereby scientific theories can fully explain. One major discrepancy between Chakravartty's (2007) and Cartwright's (1999) accounts is about their notions of laws: As for the former, causal laws are prior to dispositions, whereas the latter is confused concerning which comes first. Nevertheless, Cartwright (1999) is a fundamentalist about capacities.

Before turning to Chakravartty's (2003, 2007) account of laws, as well as the similarities between his account and that of Cartwright (1999), it is important to note that dispositions are generally explicated in terms of the four essential domains: (i) the conceptual analysis of disposition ascriptions (e.g., the conditional analysis); (ii) the dispositional-categorical distinction; (iii) the metaphysics of dispositions (e.g., natural kinds, intrinsicness and so on); and (iv) the dispositional analysis of metaphysical concepts such as causation, laws, counterfactuals, modality and so on. As for the first domain, Chakravartty (2007) argues that the "identity of a causal

property is determined by the dispositions it confers” (p. 126). Thus, no additional conceptual analysis is required. In regard to this contention, Chakravartty (2007) elucidates his stance concerning why the conditional analysis cannot work thusly:

The first [attempt] suggests that ascribing a disposition to an object is equivalent to asserting a conditional to the effect that if certain circumstances obtain, the object behaves in a certain way. Saying that sugar is soluble is simply a way of saying, for instance, that if placed in warm water, it dissolves. But this is unsatisfactory, for if circumstances favouring the manifested behaviour are *not* present, the conditional is true (given that its antecedent is false), and one must say the object possesses the relevant disposition as a matter of logic, which is absurd. The second attempt involves a more sophisticated conditional to the effect that if certain circumstances obtain, then ascribing a disposition is equivalent to attributing the manifested behaviour to the object in question. But this does not work either, for on this view one can neither affirm nor deny a dispositional ascription unless the specified circumstances favouring the manifestation occur, and this is at odds with everyday linguistic practice in which one happily describes things as fragile or soluble even if they are in no danger of breaking or dissolving. (Chakravartty, 2007, p. 125)

According to Chakravartty (2007), conditionality, in Cartwright’s terms, is then not an essential feature of dispositions in terms of the conceptual analysis. Rather, the nature or essence of an occurrent property wholly incorporates its causal functions. A causal function in turn wholly incorporates its total set of causes and effects.

Subsequently, the causal function of a property is expressed in terms of a Ramsey sentence. This is the whole story for Chakravartty (2003, 2007) concerning the characterization of dispositions.⁷² In order to elucidate his stance further,

Chakravartty (2007) argues as follows:

Since structures [(i.e., natures composed of first-order properties)] are identified with relations, there are no structures to speak of unless these

⁷²Concerning the individuation of dispositions, Chakravartty (2003) contends that: “The identity of a disposition is fixed, not by further, yet higher-order levels of properties, but by the various causal relations of which objects having are it are capable. One disposition is identical to another if and only if objects possessing them are thereby disposed to behave in the same way in exactly similar circumstances” (p. 399). This passage of Chakravartty is highly similar to those of Cartwright (1989, 1999). In particular, Cartwright’s capacities could have been identified by their own “*various* causal relations of which objects having are it are capable” (Chakravartty, 2003, p. 399). That is, conditional analysis is not the only kind of analysis whereby dispositions or capacities are characterized, but a disposition can be identified by its total set of causes and effects. Hence, Chakravartty’s notion of dispositions and Cartwright’s notion of capacities are more or less the same in terms of the semantics.

relations obtain. *Thus, particulars always have natures ... but whether or how they can be described structurally will depend on what relations they happen to be manifesting at any given time, and these may vary, depending on the circumstances* [emphasis added]. Nevertheless, given that causal properties are understood in terms of dispositions for relations, structural knowledge does contain a knowledge of properties, and thus natures. Structures are, metaphorically speaking, “encoded” in the natures of particulars, because first-order properties confer dispositions for specific relations – those one recognizes as structures. (Chakravartty, 2007, p. 43)

That is, in order to identify a disposition, one should “investigate the interactions of objects that we believe have the relevant causal property” (Chakravartty, 2003, p. 400). Once again, electrical systems, by virtue of possessing electrical charge (i.e., the Coulomb’s capacity), have the capacity to attract or repel any other system that possesses electrical charge. Note that we know where to look (e.g., electrical systems) when we investigate the Coulomb’s capacity because of the laws the capacity participates in. In this case, laws are prior to capacities or dispositions. Chakravartty (2003) is of this view: “The success of this strategy [(i.e., investigating the interactions of objects)] is explained by the fact that the causal relations of which objects are capable determine the identities of dispositions” (p. 400).⁷³

Instead of Chakravartty (2007, p. 43), Cartwright could have written the above-mentioned passage in *The Dappled World* (1999) whereby her account of capacities would be amended metaphysically. Indeed, Cartwright (1999) talks about natures, properties and capacities as Chakravartty (2007) does. In particular, Chakravartty (2007) deems all properties, as Cartwright (1989, 1999) deems all capacities, to be causally efficacious. That is, such properties are “understood in terms of dispositions for relations” (Chakravartty, 2007, p. 43). The natures of

⁷³Another textual evidence that shows the similarity between Chakravartty’s notion of dispositions and Cartwright’s notion of capacities is as follows: “[C]ausal properties simply consist in capacities of objects to act and to be affected in *various* ways in particular circumstances. Such properties would comprise *anything* from a single disposition to a cluster of dispositions, reflecting the *many-faceted* nature of causal properties generally. According to CPIT, dispositions for behaviour alone identify causal properties as the properties they are” (Chakravartty, 2003, p. 400).

particulars, which are stable, are composed of the first-order occurrent properties, which are causal, thereby such particulars always “dispose to” (or “try to”, in Cartwright’s terms) behave as they do.⁷⁴ Nevertheless, if conditionality is not a “wide spread feature of capacities”, then “capacities [or dispositions] and their manifestations are different”; and “there [will be no] need [for a] set of conditionals that connects a capacity with specific manifestations” (Cartwright, 2007b, p. 53). Then Cartwright’s account of capacities can be combined with Chakravartty’s CPIT or DIT). Subsequently, Chakravartty (2003) considers dispositions as the irreducible occurrent properties, which do not require the conditional analysis thusly:

Dispositions are distinct from and should not be confused with their manifestations. A particular disposition may facilitate the instantiation of another, which then facilitates the instantiation of another, and so on, but this does *not* entail that the original disposition is constituted by the sequence, be it actual or merely hypothetical. Recall: [R]ealists about dispositions hold that dispositions are occurrent properties in their own right. The fact that a causal property may stand in relations to others – and that its identity is determined by its *potentials* for such relations – does nothing to compromise its distinct nature. (Chakravartty, 2003, p. 400)

Ontologically speaking, dispositions, in terms of Chakravartty’s (2003) understanding, are then capacities, and vice versa. Expressly, according to Chakravartty (2003), a causal property’s or a disposition’s identity “is determined by its *potentials* for such relations [between causal properties]” (p. 400). Similarly, according to Cartwright (1999), a capacity is individuated not by “any particular manifestations”, but by “endless different manifestations of endless varieties [(i.e., its

⁷⁴Cartwright (1999) considers the link between natures, properties and capacities illustratively thereupon: “We discover the nature of electrostatic interaction between charges by looking in some very special circumstances. But the charge interaction carries that *nature* with it, from one circumstance to another. You carry the pieces from place to place, assembling them together in new ways and contexts. But you always assume that they will try to behave in new arrangements as they have tried to behave in others. They will, in each case, act in accordance with their nature” (p. 83). Once we dispense with the conditionality in characterizing dispositions, ontologically speaking, capacities can be rendered to dispositions or dispositional properties in regard to Chakravartty’s (2003) CPIT. Nonetheless, Cartwright leaves the metaphysics of capacities open to discussion thus, Chakravartty’s CPIT or DIT seems hitherto to be a promising alternative.

potentials)]” (p. 64).⁷⁵ As is already shown, if one employs the conditional analysis, capacities can only be regarded as multi-track dispositions, yet Chakravartty’s (2003) CPIT does not adhere to such an analysis. Hence, Cartwright’s account of stable, causal and natural capacities can be combined with Chakravartty’s account of dispositions. All properties have only dispositional essences after all.

As for the second domain, Chakravartty (2007, p. 126) assumes a realism about dispositions. Moreover, in his later work, Chakravartty (2017, p. 26) employs the terms “dispositions” and “dispositional properties” interchangeably. Cartwright (1999, p. 73), on the other hand, combines capacities with occurrent properties. Chakravartty (2007, p. 26) contends that all occurrent properties have only dispositional essences (i.e., dispositional properties). Although Cartwright is rather silent on this matter, if Cartwright thinks that properties or capacities are causally efficacious, then Cartwright will be a dispositional realist. Cartwright (1989) does think that thus, she is a dispositional realist.

As for the third domain, both Chakravartty (2007) and Cartwright (1999) contend that there are (dispositional) natures incorporating dispositions or capacities intrinsically. In other words, both of them are Aristotelians concerning this issue.

As for the forth domain, let us turn to Chakravartty’s (2003, 2007) account of laws and explicate the ways in which, if any, it can help to amend that of Cartwright (1999). According to Chakravartty (2007), as the modally-laden powers, causal properties determine laws and ground *de re* necessities (i.e., “objective causal

⁷⁵In a nutshell, Chakravartty (2003) expresses his theory thereupon: “According to CPIT, it is the *potential* for relations of various sorts that determines property identity. Causal property identity depends on whether any particular manifestations come to pass. Property identity does not depend on the existence of any particular relations; it is defined rather in terms of dispositions *for* relations. Dispositions on this account are discrete, occurrent properties, prior to and independent of any of the particular relations we might use to individuate them in an epistemic context” (p. 401). As is shown, Cartwright’s capacities are likewise about occurrent, natural properties that are causally efficacious.

necessities”).⁷⁶ Specifically, natural necessity (i.e., “weaker sense of necessity”), which is attributed to causal processes and laws by non-Humeans generally, is conducive in regard to the problems of ontological and epistemological identification, thereby natural necessity “applies to that which could be otherwise, but never is in a given world for some principled reason” (Chakravartty, 2007, p. 127).

Chakravartty’s (2003) CPIT gives rise to his account of laws: Properties are same if and only if they confer the same dispositions (i.e., transworld identity of properties), thereby the nature of a property determines how its instances are disposed to behave under different circumstances. Chakravartty (2007) argues as follows:

According to [CPIT or DIT], what makes a causal property the property that it is are the dispositions it confers on the objects that have it. If properties are understood this way, a simple and compelling account of natural necessity follows neatly and immediately. It is a consequence of DIT that objects with the same causal properties have the very same dispositions for behaviour, simply because of what makes these properties the properties they are. The patterns that typify causal processes are not otherwise in the actual world because of the identities of the properties they incorporate. It is in the very nature of a causal property that it confers specific dispositions and not others. That is what a causal property is. (Chakravartty, 2007, pp. 129-30)

This link between causal powers and *de re* necessities is also present in Cartwright (1999). In particular, to regard laws as about entities’ dispositions or capacities gives

⁷⁶As noted, Chakravartty (2007) distinguishes between the notion of metaphysical necessity and his peculiar notion of natural necessity, which is grounded in causal properties, thereupon: “Those who subscribe to *de re* necessity generally hold that the things to which it applies are ultimately contingent. (Some [e.g., Bird (2007)]) actually describe this necessity as metaphysical necessity, but as we shall see, what they actually intend is a qualified sort of metaphysical necessity, which even they would agree is ultimately contingent.) For the most part, those who believe that some sort of necessity is a feature of causal processes or laws of nature do not think they are metaphysically necessary, for there are possible worlds, presumably, in which causal processes and laws look very different from the sorts of things one finds and investigates scientifically in the actual world. Those who speak of *de re* necessity thus generally intend something weaker than metaphysical necessity, but this ‘something weaker’ should nevertheless distinguish genuinely causal processes from mere accidents or coincidences. This is a fine line to walk, and a difficult notion to articulate” (p. 127).

us a promising way to apprehend a non-logical (i.e., natural or metaphysical) necessity in terms of constituting nomic statements.

More importantly, both Chakravartty's account of dispositions and Cartwright's account of capacities as causal powers render our search for the property of lawlikeness otiose: Given CPIT or DIT, no extra ontological layer, neither as lawlikeness nor as "N", is required in order to account for the regularities in nature:

The *mere existence* of a given property thus serves as a truthmaker for any counterfactuals whose consequents correctly describe its possible relations. Thus, if any one party to a possible relation exists, a truthmaker for a counterfactual claim regarding circumstances under which that relation would also obtain exists also. (Chakravartty, 2003, p. 407)

What is more, both Chakravartty (2007) and Cartwright (1999) contend that when laws apply they describe the relations between dispositions or capacities.⁷⁷

Note that according to Cartwright (1999, p. 29), laws as non-linguistic and stable capacities are really the exceptionless generalizations, whereas the standard lawlike statements do not express these laws accurately. Rather, lawlike statements are strictly true if they apply to the properly-construed contexts. Otherwise, such statements are true *ceteris paribus*.⁷⁸ Cartwright (1999) contends that laws as the expressions of stable capacities are, in a certain non-logical sense, necessary.

⁷⁷Chakravartty (2007) expresses the aforementioned link thusly: "Relations between causal properties [(i.e., dispositions or capacities)], which determine how causal processes evolve, must be the ways that they are because dispositions for these specific relations make these properties the properties that they are. Laws are composed of relations, the potential for which is determined by the identities of causal properties" (p. 130). Cartwright (1999) similarly contends that: "It is capacities that are basic, and laws of nature obtain – on account of the capacities; or more explicitly, on account of the repeated operation of a system of components with stable capacities in particularly fortunate circumstances" (p. 49).

⁷⁸Cartwright (1999) argues that lawlike statements are true *ceteris paribus* thereupon: "[Lawlike statements] require in each case an implicit *ceteris paribus* clause since they describe only a single feature and its consequences; and they do not tell you what to expect when different features conflict" (p. 37).

Regarding natural necessity of laws as the expressions of stable capacities or natures, Cartwright (1999) contends thusly:

In the case of picking up pins with a magnet, the law of gravity seems to be in conflict with the law of magnetic attraction. Both need at least to be read with an implicit *ceteris paribus* clause; or better, as a description of nature of gravity or magnetic attraction. At least, there is no special problem about their truth. *Nothing about their very nature prevents them from describing the world correctly* [emphasis added]. (Cartwright, 1999, p. 37)

That is, as we have already understood, according to Cartwright (1999), laws are the exceptionless regularities of the particulars that exhibit capacities. However, lawlike statements are true *ceteris paribus* when the circumstances are not “special”

(Cartwright 1999, pp. 49-50).

Chakravartty (2007) agrees with Cartwright’s (1999) former contention as follows:

Given that specific sets of dispositions uniquely identify each causal property, relation between these properties could not be other than they are. Thus, properties in the actual world could not have entered into laws other than the actual laws. In this way, natural necessity emerges from DIT as a consequence of its identification of specific dispositions with specific properties. The idea that there is a reason why casual regularities [(i.e., laws)] are as they are in the actual world is accommodated, and its explanatory power rests in a substantive claim about the identities of causal properties. (Chakravartty, 2007, p. 130)

Such natural necessity can be combined with Cartwright’s superrealist account smoothly: The natures are determined by properties or capacities thus, worlds with the same properties will have the same capacities or natures (i.e., transworld identity). Given that laws are grounded in capacities, worlds with the same capacities will have the same laws. Like Chakravartty (2007), according to Cartwright (1999), laws are, in a non-logical sense, are necessary after all.⁷⁹ As for the latter contention,

⁷⁹Once again, Cartwright (1999) hints at this conclusion as follows: “So, ‘How does the Hume world differ from ours?’ It would not differ. Any world with the same properties as our would *ipso facto* have capacities in it, since what a property empowers an object to do is part of what it is to be that property” (p 70).

Chakravartty (2003) contends that CPIT can account for *ceteris paribus* law statements whereby the *ceteris paribus* clause is interpreted as an expression concerning dispositions. Thus, the dispositional essentialism can account for *ceteris paribus* law statements. Expressly, Chakravartty (2003) contends that such statements, if they are correct, show possible interactions between dispositions reliably:

Ceteris paribus law statements, if correct, describe relations that obtain in circumstances where no causally relevant properties other than those described are present. If objects with other potentially relevant properties *are* present, the dispositions manifested are *different* from those whose manifestations are accurately described by *ceteris paribus* law statements. (Chakravartty, 2003, p. 409)

Note that Chakravartty (2003) leaves the door open for a possible misconception concerning his idea of the nature of dispositions, namely multi-track dispositions. In particular, even though causal properties provide varieties of dispositions, they do not “confer different dispositions in different circumstances” (Chakravartty, 2003, p. 409). That is, according to Chakravartty (2003), the set of dispositions a causal property has, and all the dispositions that a property can possibly confer, is fixed by the nature of that property. Nevertheless, Chakravartty (2003) acknowledges that “[w]hich dispositions are manifested in a given situation will depend on the assortment of causal properties involved” (p. 409).⁸⁰

Overall, both Chakravartty and Cartwright contend that although, in most situations, law statements require the *ceteris paribus* clause, laws as regularities are

⁸⁰Concerning how CPIT accounts for *ceteris paribus* law statements, Chakravartty (2003) adds: “Thus, whether *ceteris paribus* expressions are useful in different contexts will in each case depend on how closely they approximate the relations that obtain. Thus, we often use law statements as idealizations – we apply expressions to situations that are, in fact, more complex than those they properly describe. Though not strictly accurate in their characterizations of dispositions presently manifesting, such dispositions are often ‘good enough’ for predictive or explanatory purposes” (p. 409). Note that Chakravartty’s (2003) argument is in line with that of Cartwright (1999): Laws are exceptionless regularities, but the statements that refer to them require the *ceteris paribus* clause since real-world situations, in general, are not ideal.

exceptionless generalizations due to the instantiations of dispositions or capacities. In other words, it is in the dispositional nature of bodies that they have the capacity to, say, attract one another in virtue of their mass (i.e., the gravitational capacity). Indeed, this is strict. However, the statements that describe capacities involve the ceteris paribus clause since we do not “generally specify all of the potentially relevant dispositions that comprise the set properly associated with a given causal property” (Chakravartty, 2003, p. 409). Ceteris paribus, all bodies attract one another in virtue of their gravitational capacity. Similar to Chakravartty (2003), Cartwright (1999, pp. 50-51) thinks that nomological machines, which are grounded in capacities after all, do not operate repeatedly in some situations because the relevant properties are not distributed ideally across the spatiotemporal manifold.⁸¹ Once again, according to Cartwright (1999) and Chakravartty (2003), laws themselves are the exceptionless generalizations due to their stable natures. Pragmatically speaking, despite requiring the ceteris paribus clause in most cases, law statements hitherto work adequately in terms of explaining and predicting scientific phenomena regardless.⁸² Last, Chakravartty (2003) explicitly presents his stance concerning the relation between causal properties and laws as follows:

Speaking metaphorically, all of the relations of which causal properties are capable are ‘encoded’ in the dispositions they confer. Properties and laws are thus flipsides of the same coin. Some [(e.g., Mumford (1998))] will be tempted here to claim that properties are ontologically prior to laws. If laws are relations between properties, and the natures of properties determine what relations are possible, it would seem that laws are dependent on the natures of

⁸¹Like Cartwright (1999), Chakravartty (2003) continues as follows: “The presence or absence of objects with other causal properties will determine whether the outcomes predicted by law statements for concrete cases of causation are manifested, but such occurrences are irrelevant to the question of whether *ceteris paribus* expressions correctly map *some* possible relations. The relations they describe may be laws of nature regardless” (p. 409).

⁸²Chakravartty (2003) contends that exceptionless and general causal laws help us make sense of *ceteris paribus* law statements thereupon: “All planets in solar systems move in approximately elliptical orbits’, if a true generalization, does not appear to make reference to properties that are causally related in the appropriate manner. Perhaps in such cases one could argue that there are in fact causal laws which entail these regularities, *regardless of whether we are presently able to supply the relevant law statements*; perhaps the same could be said about putative conservation laws” (p. 410).

properties. If one accepts that dispositions are genuine properties whether or not they are manifested, it is tempting to say that laws are (in a sense) actual, whether or not they are actualized. On this view, uninstantiated but possible relations exist, in potential form, ready under appropriate circumstances for actualization. (Chakravartty, 2003, p. 408)

That is, Chakravartty's CPIT supports the notion that causal properties and laws are the "flipsides of the same coin" (Chakravartty, 2003, p. 408). This stance is akin to that of Cartwright (2008, pp. 195-97). The natures of properties, which are solely dispositional, are such that we can explain and predict scientific phenomena in virtue of them.⁸³ Since we have shown that it is a promising endeavor to combine Cartwright's account of capacities with Chakravartty's CPIT, let us look at whether CPIT or DIT can answer Psillos's (2002, 2008) questions concerning capacities.

4.5.1 Woes and amendments

Before going further, note that this thesis does not try to explicate the generic epistemological and the metaphysical objections to the DE view of properties.⁸⁴ Rather, I will thoroughly explicate Chakravartty's (2010, 2013b, 2017) realist position regarding dispositions in the fifth chapter of this thesis - in particular, Chakravartty's (2010, 2013b, 2017) arguments about why dispositions can save scientific phenomena.

⁸³Chakravartty (2003) contends that the natures of properties determine what is physically possible (and necessary) according to CPIT: "Recall that it is a consequence of CPIT that networks of causal properties have a holistic nature. This furnishes a more radical solution to the problem of truthmaking than is generally appreciated. The existence of any *one* causal property is a sufficient truthmaker for counterfactuals about all possible relations applicable to the world in which that property is found. This is because ... the identity of a causal property is determined by its dispositions for relations with other properties. Given that these links map the various ways in which properties by their very natures can be related, this network of properties and potential relations comes as a package, or not at all. The existence of any one property, then, is sufficient to determine the natures of all possible properties and relations in the network to which that property belongs" (pp. 407-08).

⁸⁴See Rosenberg (1984, p. 82) and Swinburne (1980). For arguments concerning why dispositions are redundant (or otiose), see Mackie (1977, p. 366) and Earman (1984, p. 203).

As noted, Psillos's (2002) questions concerning Cartwright's (1989, 1999) capacities are raised because of lack of a metaphysical account about such capacities: "Talk of capacities is not necessarily problematic. Yet it is not well grounded if it is not accompanied by a theory of what they are, how they are manifested, what individuates them, what governs their manifestation, and so on" (Psillos, 2002, p. 196). Would grounding capacities in accordance with CPIT be of any help in reducing Psillos's (2002) worries?

As to the nature and the individuation of capacities or dispositions, according to CPIT, there is "nothing more to being a particular causal property than conferring certain dispositions for behaviour" (Chakravartty, 2003, Abstract). Then, as noted in the previous sub-heading, the nature or essence of a property wholly incorporates its causal functions. A causal function in turn wholly incorporates its total set of causes and effects. Technically, Chakravartty (2007) contends that the causal function of a property is expressed in terms of a Ramsey sentence. Not only that, but also laws, as the causal relations between causal properties, "distinguish and identify properties as well" (Chakravartty, 2003, p. 394).⁸⁵ This notion is also akin to that of Cartwright: What identifies a capacity is "the occurrence of the canonical behaviour we associate with [that] capacity" (Cartwright, 2008, p. 195). It is "canonical" because of the laws such a capacity "participates in" (Cartwright, 2008, p. 195). Roughly speaking, capacities are the occurrent and causally efficacious properties that only have

⁸⁵Chakravartty (2003) contends: "A causal property may be identified as the property that it is in virtue of its relations to other properties. The conjunction of all causal laws thus specifies the natures of all causal properties" (p. 394). Subsequently, he adds: "The best strategy we have for identifying a disposition is to investigate the interactions of objects that we believe have the relevant causal property. The success of this strategy is explained by the fact that the causal relations of which objects are capable determine the identities of dispositions" (Chakravartty, 2003, p. 400). As noted, Cartwright (2008, pp. 195-97) replies to Psillos (2008) in a similar fashion after all.

dispositional essences, i.e., “causal properties just *are* dispositions” (Chakravartty, 2003, p. 400).⁸⁶ Chakravartty (2003) adds as follows:

That is, causal properties simply consist in *capacities to act and to be affected in various ways in particular circumstances* [emphasis added]. Such properties would comprise anything from a single disposition to a cluster of dispositions, reflecting the many-faceted nature of causal properties generally. According to CPIT, dispositions for behaviour alone identify causal properties as the properties they are. (Chakravartty, 2003, p. 400)⁸⁷

Unless dispositions are identified with their canonical manifestations (or, dispositions for behaviour), then it will be plausible to characterize them either as conventional or multi-track dispositions. As is shown by now, neither Chakravartty (2003, 2007) nor Cartwright (1989, 1999) identifies a disposition with a single manifestation. For instance, the property of mass is not the disposition or capacity to attract other massive bodies if the relevant condition is met. Rather, it is a stable and causally efficacious property that can be manifested in various different ways under possibly numerous conditions. At certain times, a massive body attracts; it sometimes repels; at other times, it does not manifest itself at all. Nevertheless, the property is called “mass” because of its inherent dispositions for its relevant behaviors. It is irrelevant for the nature of mass whether its dispositions are manifested or not. So far so good.

As to the manifestation and the governance of capacities or dispositions, since capacities themselves are the occurrent causal properties such as mass, charge and so

⁸⁶Concerning the natures or dispositional essences of properties, Chakravartty (2003) argues: “They [(i.e., properties)] are identified as members of a class of properties on the basis of similarities in the dispositions they confer. A case could be made that this represents an intuitive approach to property terms. Some use ‘mass’ to refer only to properties that confer the same dispositions as mass properties in the actual world; others use the term to pick out properties across worlds whose associated dispositions are sufficiently similar ... if *per impossible* the property we call ‘mass’ were associated with different dispositions in some possible world, it would clearly *not* be what we call ‘mass’ (pp. 403-04).

⁸⁷Cartwright (1999) likewise contends that: “I say that Newton’s and Coulomb’s principles describe the capacities to be moved and to produce motion that a charged body has, in the first case the capacity it has on account of its gravitational mass and in the second, on account of its charge” (p. 65).

on, such capacities may “facilitate the instantiation of another, which then facilitates the instantiation of another, and so on, but this does not entail that the original disposition is constituted by the sequence” (Chakravartty, 2003, p. 400). That is, it is a simple fact that occurrent and natural properties produce manifestations. That is, it is a truism that at certain times properties instantiate. What governs properties’ or capacities’ manifestations is laws, which “often involve reference to other capacities” (Cartwright, 2008, p. 195). According to Cartwright (1999), such laws themselves are the relations between properties. Linguistically speaking, lawlike statements are the capacity claims.⁸⁸ “Governs” here is used metaphorically; the term signifies the ontological priority of laws to causal powers, dispositions or capacities.

Of course, all the aforementioned amendments depend on one essential assumption that is made both by Cartwright (1989, 1999) and Chakravartty (2003, 2007): Dispositions or capacities are real, occurrent and natural properties (i.e., dispositions are the properties that sciences study.) In this chapter, the arguments regarding the reality of dispositions are not explicated (cf. Chakravartty, 2010, 2013b, 2017). That task is left for the fifth chapter. Now, we will turn to the other alternative in order to provide a new metaphysics of Cartwright’s account of capacities as dispositions or dispositional properties (i.e., capacities as multi-track dispositions).

4.6 Capacities as multi-track dispositions: Ability analysis

Let us analyze the other alternative in detail: Combining capacities with multi-track dispositions. Before going further, note that this thesis does not try to explicate

⁸⁸As noted, Chakravartty’s (2003) CPIT neatly combines with Cartwright’s account of capacities concerning this issue as well: “[N]ot only are laws composed of relations between causal properties; [laws] distinguish and identify properties as well” (p. 394).

whether all dispositions are multi-track, or whether multi-track dispositions are reducible to the complex conventional ones (cf. Bird, 2009, pp. 226-27). What is more, this thesis does not try to examine the conceptual problems concerning multi-track dispositions – especially, the distinction between categorical and dispositional properties (cf. Ellis, 2001, p. 45; Bird, 2007, pp. 66-67). For the argument's sake, we simply assume that at least some (real) dispositions are irreducibly multi-track.⁸⁹

The paramount aim of this sub-heading is to show that capacities are not conventional dispositions, but multi-track ones. Vetter (2013, 2014) and Fara (2005) offer related analyses concerning the multi-track nature of dispositions.⁹⁰ Since no version of the conditional analysis of dispositions is able to capture capacities semantically, one promising way to establish that capacities are multi-track dispositions is through my ability analysis of disposition ascriptions.⁹¹ In addition, there are insurmountable structural problems that heavily weaken the force of the CA (cf. Martin, 1994; Bird, 1998; Molnar, 2003). In other words, I will try to give an analysis of dispositions without a stimulus.

First, we simply assume that there are multi-track dispositions both qualitatively and quantitatively. As for the qualitative variety, one can argue that a

⁸⁹For the semantics of disposition ascriptions, see D. H. Mellor (2000, pp. 757-80) and T. Cross (2005, pp. 321-41).

⁹⁰Vetter's (2014) primary aim is to provide an analysis of dispositions without conditionals. She supports the idea that there are multi-track dispositions. Nevertheless, she does not expressly state whether capacities can be deemed as multi-track dispositions. That is this thesis' aim. The same goes for Fara (2005).

⁹¹The simple conditional analysis (SCA) is subject to many counterexamples, which can be classified under three main headings: (i) what if dispositions are "finkish" (ii) what if dispositions are "masked" (iii) what if dispositions are "reverse masked" (i.e., "mimicked") (cf. Lewis, 1997; Fara, 2005; Handfield & Bird, 2008; Manley & Wasserman, 2008). In order to amend the CA, Lewis (as cited in Schlosser, 2017, p. 4) proposed a reformed conditional analysis (RCA): "S is disposed to M when C if and only if S has some intrinsic property B in virtue of which S would M if C and if S were to retain B". Although the RCA could deal with the problem of finkish dispositions, it is unable to cope with the problem of masking (and mimicking). Of course, there are amendments concerning the RCA (cf. Choi, 2006; Steinberg, 2010). Nonetheless, as noted, no version of conditional analysis is amenable to us since Cartwright's account of capacities cannot be accounted with a single pair of stimulus condition and manifestation.

canonical disposition (i.e., fragility) is multi-track because it has various different qualitative stimulus conditions: A fragile object manifests its disposition under various different conditions (e.g., dropping, throwing, being exposed to 140 decibels (dB) voice, being exposed to very high temperatures, and so on). That disposition is also quantitatively multi-track: A fragile object manifests its disposition by being exposed to a force of 10 N, 50 N or 100 N and so forth. Different stimulus conditions of a single disposition come in degrees. That is, stimulus conditions are quantitative.

Second, following Cartwright (1999), we assume that such dispositions are real, irreducible and causally efficacious. For the sake of argument, we consider Cartwright (1999) as a dispositionalist, as we have done in the previous sub-heading, regarding the metaphysics of dispositions. Third, we assume that scientific practice essentially refers to such dispositions in terms of explaining phenomena and making predictions. Indeed, Cartwright (1999) holds that science aims to discover (multi-track) dispositions or capacities, thereby we can understand scientific phenomena more accurately.

Before expressing a characterization of dispositions through my ability analysis, let us present Vetter's (2013, 2014) and Fara's (2005) accounts, respectively. Both Vetter (2014) and Fara (2005) offer a semantics of dispositions without appealing to subjunctive conditionals (i.e., dispositions without a stimulus). After sketching those two accounts, I will try to give a related, but different semantics of dispositions without a stimulus (i.e., ability analysis).

Now, following Vetter (2013, 2014), we turn to a characterization of dispositions through possibility analysis. It is important to note that this thesis offers a different alternative than that of Vetter (2014, pp. 134-35). It is also important to

note that Vetter (2014) likewise offers a non-conditional analysis of multi-track dispositions after all.

Vetter (2013) starts her journey by alluding to linguistics. Expressly, two canonical examples of multi-track dispositions are: (i) “disposed to be soluble” and (ii) “disposed to be fragile”. In terms of lexicography, according to the *Oxford English Dictionary*, “soluble” means: “(Of a substance) able to be dissolved, especially in water” (The Oxford English Dictionary, n.d.); “fragile” means: “(Of an object) easily broken or damaged” (The Oxford English Dictionary, n.d.).⁹² Vetter (2013, p. 347) readily contends that linguistic intuitions do not generally offer help in terms of making judgments about metaphysical proposals since the ordinary uses of terms are vastly different from the theoretical ones. Nonetheless, dictionary definitions may “suggest a conception of dispositionality that provides the simplicity and unity [that] a more standard, conditional based, conception of dispositions [lacks]” (Vetter, 2013, p. 347).⁹³

In addition to Vetter’s (2013) claims, one can argue that dispositional terms such as fragility and solubility are not theoretical per se, thereby ordinary objects that are classified as fragile have a common characteristic that non-fragile objects lack: Fragile objects are able to be broken expectedly. This rendition of dispositions helps us to dispense with conditionals in terms of analyzing dispositions: “In general, what characterizes the nature of a disposition ... is primarily what the objects so disposed [to] do and not, or only derivatively, what they would do under specific

⁹²Soluble. (n.d.) In *The Oxford English Dictionary*. Retrieved from <https://en.oxforddictionaries.com/definition/soluble>. Fragile. (n.d.) In *The Oxford English Dictionary*. Retrieved from <https://en.oxforddictionaries.com/definition/fragile>.

⁹³In her later work, Vetter (2014) adds: “Why is this important? I am certainly not advocating that philosophy be replaced by linguistics or lexicography, but I do take these data to provide some motivation for an alternative approach. If dispositional terms linguistically express a kind of possibility, the default assumption should be that the properties ascribed with them are possibility-like. Linguistic considerations motivate an alternative approach to dispositional properties: one that characterizes their modal nature not in terms of a conditional, but in terms of possibility” (p. 131).

circumstances” (Vetter, 2013, p. 347).⁹⁴ Thus, there is an alternative analysis of dispositions without a stimulus that can account for counterfactuals without resorting to conditionals.

By taking fragility as the paragon example of dispositions, Vetter (2013) offers an alternative non-conditional analysis of multi-track dispositions, in such a way of her possibility analysis (PA) as follows:

(PA) x is fragile iff [sic] x can break (easily) (p. 348).⁹⁵

At certain times, fragile objects do not break expectedly because finkish and masking dispositions interfere. We can insert the *ceteris paribus* clause into the aforementioned symbolization, thereby finkish and masking dispositions are left aside, in such a way of my reformed possibility analysis (RPA):

(RPA) x is fragile if and only if x is able to be broken expectedly finkish and masking dispositions aside.

It is important to note that, according to both Cartwright (1999) and RPA, the *ceteris paribus* clause (i.e., “finkish and masking dispositions aside”) concerns dispositions alone. That is, it is not the case that laws hold only *ceteris paribus*. However, the problems of finkish and masking dispositions merely challenge the subjunctive conditional analysis of dispositions. That is, such problems could undermine the force of PA if and only if PA assumes that there is a deep connection between a disposition’s stimulus condition and its manifestation. However, Vetter

⁹⁴Vetter (2014) relatedly argues: “On the alternative approach that I am suggesting, this kind of complexity disappears: [T]he multitude of putative stimulus conditions is no longer part of a disposition’s characterization [(i.e., dispositions are multi-track.)] We can simply think of fragility as the disposition to break and of loquaciousness as the disposition to talk, and then capture both of these dispositions by a corresponding possibility claim” (p. 132).

⁹⁵This thesis tries to offer a related but different analysis. One essential difference between the two analyses is that in her symbolization, Vetter (2013) particularly employs the term “easily” instead of “expectedly”. I prefer “able to” and “expectedly” because they directly refer to the dispositional essences of causal properties. Fragile objects are those objects that are hitherto able to be broken expectedly. It is in their dispositional essences to be broken as they are expected to do, i.e., they are “disposed to” do so (cf. Chakravartty, 2003, 2007).

(2013) explicitly identifies dispositions by their manifestations alone. Since multi-track dispositions are not identified with a single pair of stimulus condition and manifestation, according to PA, a property manifests itself in various different ways or it does not manifest itself at all whether there are interfering finkish dispositions or not. Hence, PA endures its argumentative force; thus, RPA is redundant.⁹⁶

Nevertheless, this notion of “other things being equal” is perfectly on par with that of Cartwright (1999). So far so good.

The template of Vetter’s (2014) possibility analysis of dispositional properties is thereupon:

- (1*) A disposition is individuated by its manifestation alone: it is a disposition to M, fullstop [*sic*].
- (2*) Its modal nature is that of possibility, best characterized (to a first approximation) by ‘x can M’. (Vetter, 2014, pp. 134-35)

Vetter’s (2014) thesis is twofold: (i) a disposition is not characterized by any pair of a stimulus condition and a manifestations, but only by its manifestation; and (ii) the modal nature of a disposition is a possibility “with the disposition’s manifestation as its actualization” (Vetter, 2014, p. 145). The modality about possibility is of two kinds in regard to dictionary definitions: (i) “some dispositions are characterized by *easy* possibility (e.g., “easily destroyed”) and (ii) the others by “possibility *simpliciter*” (e.g., “capable of being melted”) (Vetter, 2014, p. 135). Concerning the relation between her possibility analysis and the disposition ascriptions, Vetter (2014) contends thusly:

‘The vase is fragile’ expresses the possibility that the vase breaks *given* its intrinsic make-up. It is true just in case the vase breaks in some relevant possible world; and into the conditions for a world to count as relevant we build, among other things, the condition that the intrinsic constitution of the vase itself, or even only parts ... is held fixed, while contingent circumstances

⁹⁶Vetter (2014) concludes: “Similarly, a vase that has its fragility masked by anti-deformation packaging remains fragile, despite the falsity of the corresponding conditional, precisely because its fragility is a property of the vase. It is a matter of how things stand with the vase, not with the anti-deformation packaging” (p. 133).

external to the object are not. Thus, a glass's molecular constitution and the fact that it has a slight crack will be the same in all the relevant worlds, but the fact that it is packed in styrofoam [*sic*] as opposed to standing near the edge of a table will not. (Vetter, 2014, p. 136)

Analyzing this passage through Cartwright's (1999) glasses is as follows: The vase is fragile because it can break, or because of its capacity to be broken. That is, a causal property has the dispositional essence, or the "nature" in Cartwright's terms, whereby it manifests its capacity. If the vase breaks once, then it is sufficient to establish that the property has the relevant stable capacity (Cartwright, 1999, p. 136). If the vase is able to break, then it is fragile. Contingent circumstances external to the object may bring about different manifestation of the same object although the capacity of the object remains stable in each circumstance (Vetter, 2014, p. 136).

As to the individuation of multi-track dispositions, assuming that Cartwright (1999) is a dispositionalist, Cartwright (1999) could argue that PA identifies the dispositional essences of causally efficacious properties (cf. Chakravartty, 2003, 2007). Subsequently, the truthmaker of an ability claim would be the relevant causal or dispositional property itself: A plate is able to be broken expectedly because it is fragile, and not vice versa. Or, following Vetter (2013), possibility claims would be "no more than imperfect approximations to the corresponding disposition" (p. 349). Nonetheless, through PA, capacities or dispositions can be individuated not by "any particular manifestations", but by "endless different manifestations of endless varieties" (Cartwright, 1999, p. 64). Nevertheless, capacities are individuated by manifestations alone because, according to PA, dispositions are multi-track.⁹⁷

⁹⁷Concerning her account of the semantics of disposition ascriptions, Vetter (2014) contends: "Disposition ascriptions, on this picture, are akin to possibility statements, but they differ in their degree of flexibility. Take a fragile vase packed in protective packaging. There is no doubt that the vase is still fragile. But can it break? *Yes and no, depending on the context* [emphasis added]" (p. 136).

When the Coulomb's capacity manifests itself under laboratory conditions, we observe that like charges repel, and alike charges attract each other approximately (Cartwright, 1999, p. 18). However, since real life conditions are messy or dappled, charges do not always behave as they generally do when interfering factors are present. In a nutshell, although capacities, dispositional essences or properties are stable, such capacities are ultimately multi-track. When a body has the Coulomb's capacity, it carries that exact same capacity wherever it is present. Thus, they can give rise to "endless different manifestations of endless varieties" (Cartwright, 1999, p. 64). Vetter (2013) sketches a similar picture as follows:

A plausible realist picture of dispositions [(e.g., that of Cartwright (1999))] will start with a general conception of powers or capabilities to do or to be such-and-such. It will hold, further, that these powers come in degrees. For a disposition ascription such as 'Ming is fragile' to be true, Ming's power will have to have a certain, contextually fixed, minimum degree. Powers and their degrees will remain primitives on such a view. But that is as it should be. (Vetter, 2013, p. 349)

According to Cartwright (1999), causal powers or capacities will have their certain contextually fixed minimum degree because capacities are grounded in their natures, which are dispositional alone, whereby a capacity can be identified as the capacity it is. On the other hand, such capacities come in degrees because at certain times irrelevant factors are not held equal (i.e., capacities are multi-track.) That is, if finkish and masking dispositions interfere, then, say, the Coulomb's capacity will not bring about its canonical manifestation (i.e., a single object does not have a fixed set of manifestations.)

Can PA of capacities or dispositions account for the scientific image of the world? Yes, it seems so. Initially, as is already shown, Cartwright's notions of natures, properties and capacities are not amenable to the subjunctive conditional analysis due to, in particular, such capacities' malleability, which does not concern

the natures or essences of properties, but manifestations alone. What is more, Capacities are stable, occurrent, natural and yet causally efficacious properties (cf. Chakravartty, 2003, 2007). Thus, such capacities are, in a certain sense, natural dispositions.⁹⁸ Vetter (2013) highlights how multi-track dispositions without a stimulus can better accord with laws of nature as follows:

The conditional conception has prompted it to accord a greater degree of naturalness to the highly specific, single-track dispositions, than to the more familiar multi-track ones. This would lead us to expect that the perfectly natural dispositions are highly specific too. At the fundamental level, then, we do not find properties such as charge ... but such highly specific disposition as the disposition to repel objects of charge e^- at a distance of exactly $5.3 \times 10^{-11} m$. But there are no independent reasons, apart from the conditional conception, to form such an expectation. (Vetter, 2013, p. 351)

Since we do not adhere to any version of the CA in terms of characterizing dispositions, it is not plausible to think that the perfectly natural dispositions, whose relations are described by laws of nature, are highly specific. Rather, at the fundamental level, there are natural properties such as the gravitational capacity and charge because such properties are malleable or multi-track. Yet, at the same time, their dispositional essences or natures are stable.⁹⁹ Vetter (2013) further contends thusly:

We tend to think that the more natural properties figure in the more fundamental laws; and that the laws and properties dealt with in physics are more natural than those dealt with, say, in sociology. But physics is better understood to be dealing with charge and other equally general dispositions. It is the general dispositions, not the highly specific ones, that correspond to the laws of physics. Instances of [Coulomb's] law ... follow from the general law and should not be prior to it, on pain of raising the question why there is such mathematical uniformity among them. Accordingly, charge itself has a better claim to be a (nearly) perfectly natural disposition than the specific dispositions described. If anything, [physics] advises an ordering that takes

⁹⁸Cartwright (1999) can even be considered as an austere dispositionalist: A supporter of the idea that there are only natural (or sparse) dispositions.

⁹⁹Vetter (2014) contends: "Note that this does not entail that dispositions are incompatible with necessity. For all I have said, an object may be disposed to [x] and be necessarily [x], or very nearly necessarily [x]" (p. 144). Especially, Vetter's notion of "very nearly necessarily [x]" can be understood in terms of Chakravartty's (2007, p. 131) notion of natural necessity, thereby causal laws would be characterized as "relations between causal properties" (Chakravartty, 2007, p. 122).

such general dispositions as charge to be prior to the highly specific dispositions. (Vetter, 2013, pp. 351-52)

One central impetus behind the above-mentioned quoted passage is that dispositions or capacities are not to be confused with their canonical manifestations and stimulus conditions. Such a confusion would lead us to surmise that, at the fundamental level, sciences study the highly specific dispositions that are characterized by numerous subjunctive conditionals alone. Rather, such properties should be characterized by their stable, natural, occurrent and yet causally efficacious dispositional essences, which can give rise to “endless different manifestations of endless varieties” (Cartwright, 1999, p. 64).¹⁰⁰ Thus, if characterized through PA, “charge [or the Coulomb’s capacity] itself has a better claim to be a (nearly) perfectly natural disposition [than] the specific dispositions described” (Vetter, 2013, p. 352).

Like Vetter (2013, 2014), Fara (2005) acknowledges thusly: “Sometimes the dispositions of objects fail to manifest themselves, even when their conditions of manifestation obtain” (p. 43). However, Fara (2005) adds: “[N]o conditional account can reflect the fact that ... dispositions may fail to become manifest even when their conditions of manifestation obtain” (p. 46). Fara’s (2005) non-conditional analysis is different than that of Vetter (2013). In particular, according to Fara (2005), instead of conditionals, one should use habituais in characterizing dispositions. In regard to manifestations, habituais identify how an object generally behaves. “Like charges repel each other” is true even if, at certain times, they fail to do so. According to Fara (2005), this particular feature of habituais makes them well-suited in terms of

¹⁰⁰See Vetter (2012) for her argument concerning why the dispositional properties cannot ground laws of nature unless we dispense with the subjunctive conditional analysis of such properties.

identifying dispositions.¹⁰¹ As for the semantics of habitual sentences, Fara (2005) contends as thusly:

Habituals tolerate some, but not all of their counterinstances [*sic*]. If every counterinstance [*sic*] to a habitual is *acceptable* or *permissible* (in some technical sense to be supplied), then that habitual is true; but if a habitual has an *unacceptable* or *impermissible* counterinstance [*sic*], then it is false. Given a habitual of the form ‘*N Ms when C*’, let an *exception* to that habitual be any case in which *C* but in which *N* isn’t *M*-ing. (Fara, 2005, p. 66)

The symbolization of “the exception-tolerating semantics” is: “A habitual ‘*N Ms when C*’ is true iff [*sic*] every exception to the habitual is a permissible exception” (Fara, 2005, p. 66). Note that Fara (2005) does not “explain what it takes for an exception to a habitual to be permissible” (p. 68). As for the semantics of disposition ascriptions, Fara (2005) expresses the truth conditions of disposition ascriptions as follows:

‘*N* is disposed to *M* when *C*’ is true iff [*sic*] DISP (*N Ms when C*) (p. 69).

In this symbolization, “‘*N*’ is to be replaced by a noun phrase, ‘*M*’ by a verb phrase, and ‘*C*’ by a sentence” (Fara, 2005, p. 45). Concerning the interpretation of “DISP”, Fara (2005) argues as follows:

DISP(*N Ms when C*) is true only if *N Ms when C*. If a barrel is *disposed* to roll when pushed, then it rolls when pushed. Sentences such as [“Elastic bands are disposed to stretch when pulled, and they do not stretch when pulled”] do not just sound odd ... [but] trivially false, absurd. (Fara, 2005, p. 69)

What is more, Fara (2005) states that “DISP” is not reducible to ordinary statements thereupon:

First, it seems that adding “disposed” serves to rule out accidents of a certain kind. If, by unfortunate coincidence, Tristram happens to be standing near an earthquake each time he’s angry, and so is caused to tremble, it would be true to say that he trembles when he’s angry, but not that he’s disposed to do so. Second, adding “disposed” attributes some kind of responsibility to the subject of the sentence. To put the point another way: [T]o attribute to an

¹⁰¹“If the truth of a habitual sentence need not require that its subject have a certain habit, what then does it require? A natural suggestion is that habituals have something to do with what is *normally*, or *typically*, or *generally* the case” (Fara, 2005, p. 64).

object a disposition to do so-and-so is to say not just that it does so-and-so, but that it has some intrinsic property in virtue of which it does so-and-so. (Fara, 2005, pp. 69-70)

Subsequently, Fara (2005) expresses his habitual account: “‘*N* is disposed to *M* when *C*’ is true iff [sic] *N* has an intrinsic property in virtue of which it *Ms* when *C*” (Fara, 2005, p. 70). Interpreting by Cartwright’s terms, a capacity claim “The sun is disposed to exert a force on the moon when so-and-so” is true if and only if the sun has an intrinsic property, which is the causally efficacious and stable gravitational capacity, in virtue of which it exerts the force on the moon when so-and-so. Since the capacity is multi-track, there are certain cases in which it does not manifest itself at all. It is important to note that the capacity is disposed to manifest itself after all.

Overall, the merits of habitual account are as follows: (i) the account “seems to make the right predictions about the truth values of the disposition ascriptions that we make. Not only does sugar dissolve when put in water ... it also has an intrinsic property in virtue of which this is so” (Fara, 2005, p. 70); (ii) the account “provides truth conditions for some disposition ascriptions that conditional accounts cannot even accommodate ... which lack explicit statements of manifestation conditions” (Fara, 2005, p. 70); and (iii) the account “can solve the problem of masking” (Fara, 2005, p. 71).¹⁰²

This thesis proposes a new non-conditional analysis of multi-track dispositions, which, in a sense, amalgamates Vetter’s (2013, 2014) and Fara’s (2005) accounts. It differs from that of Vetter (2014) because her characterization of dispositions by “easy possibility” (p. 135) does not refer to the intrinsic natures or properties of objects directly. Indeed, it concerns the degrees of causal powers: Some objects are more easily destroyed than others. However, it does not concern the

¹⁰²Concerning how Fara’s (2005) account can solve the problems of masking and finkish dispositions, see Fara (2005, pp. 71-78).

malleability of a single disposition or a single capacity. In other words, if there is an instance in which an object breaks, then it is sufficient to count that object as breakable. That is, the only modality pertaining to dispositions or capacities is “possibility *simpliciter*” (Vetter, 2014, p. 135). If interpreted through Cartwright’s glasses: “A single successful case is significant, since that guarantees that the causal factor [(i.e., dispositional property)] does indeed have the capacity it needs to bring about the effect” (Cartwright, 1989, p. 136). As noted, Cartwright (2008, p. 195) admits that although laws refer to capacities, they are prior to capacities. Laws determine what is nomically necessary and possible. Nevertheless, objects have capacities or causal properties, which are identified by the laws, in virtue of which they are able to give rise to various different behaviors.

As for the difference from Fara’s (2005, p. 69) account, in the upcoming symbolization “when *C*” is not needed to give a non-conditional analysis of dispositions because dispositions are deemed to be essentially multi-track.

It is important to note that although Fara (2005) provides a non-conditional analysis, Fara (2005) does not expressly support the notion that there are multi-track dispositions. Overall, my ability account (AA) of (multi-track) dispositions is as follows:

(AA) “*N* is disposed to *M* expectedly” is true if and only if *N* has an intrinsic capacity in virtue of which it *Ms* expectedly.¹⁰³

“The sun is disposed to exert a force expectedly” is true if and only if the sun has an intrinsic capacity (i.e., a causally efficacious dispositional property on which its multi-track dispositions are based) in virtue of which it exerts the force expectedly. It is “expectedly” because ontologically prior laws hitherto identify the

¹⁰³“Intrinsic capacity” refers to the occurrent properties that have dispositional essences alone, i.e., multi-track dispositions.

capacity whereby its related canonical manifestation occurs: We expect those manifestations that the causal laws determine. Nevertheless, as Cartwright (2008) contends, such laws “involve reference to other [intrinsic] capacities [(i.e., causal properties)]” (p. 195). Since we try to combine capacities with multi-track dispositions, such laws are taken in AA as Cartwright (1999) takes them in her account. Expressly, the two notions of law are more or less identical: In a world where the dispersion of capacities across the space-time continuum was the same, the laws would be the same; whereas in a world where there are different nomological machines, the laws would be different.

That is, laws would be naturally, not metaphysically, necessary. That is the end of the story about the relation between capacities and laws according to Cartwright (2008): “I [do not] object to the existence of ‘laws’ that demand that different specific capacities occur together. I certainly would not admit them in order to explain why [capacities] occur together as I don’t see why that needs explanation” (p. 197).

Again, since capacities are multi-track, there are some cases in which the unexpected manifestations occur – or no manifestation occurs at all. Nevertheless, the dispositional nature of an object is stable: The set of multi-track dispositions or capacities associated with an object with a dispositional property is stable, whereas the occurrent behaviors are malleable. Like Chakravartty (2013, 2014), according to AA, all causal properties or capacities have dispositional essences alone. The notion of capacity that is employed in AA is exactly the same as Cartwright’s notion of capacity. But, unlike Cartwright (1989), a capacity is explicitly taken as a dispositional property. Such an amalgamation of Vetter’s (2013, 2014) and Fara’s

(2005) theories can account for Cartwright's account of capacities as multi-track dispositions.

There are several counter-arguments against Vetter's (2013, 2014) and Fara's (2005) accounts, which are beyond the scope of this thesis.¹⁰⁴ What is more, the proposed AA is clearly underdeveloped and highly provisional, but developing AA in more detail is also beyond the scope of this thesis.¹⁰⁵ That project is left for future studies. As noted, the primary aim in this chapter is to show that a new metaphysics of Cartwright's account can be given. The two most promising alternatives are: (i) subsuming Cartwright's account of capacities under Chakravartty's (2003, 2007) CPIT or DIT and (ii) combining capacities with multi-track dispositions without a stimulus.

Nonetheless, the cogency of these two alternatives depends on a crucial assumption: Irreducible causal powers, dispositions or dispositional properties are real and detectable in the scientific landscape. In the next chapter, this thesis tries to explicate the arguments, especially those of Chakravartty (2007, 2010, 2013b, 2017),

¹⁰⁴See Yli-Vakkuri (2010) for serious criticisms against Fara (2005). See Choi (2006, 2008) for arguments concerning why we should stick to conditional analyses about the semantics of disposition ascriptions.

¹⁰⁵Nonetheless, let us try to answer Psillos's (2002, p. 196) questions provisionally. Given that capacities are rendered to multi-track dispositions via AA: (i) there is "nothing more to being a particular causal property than conferring certain dispositions for behaviour" (Chakravartty, 2003, Abstract). That is, all properties have dispositional essences alone, and we ascribe dispositions or capacities to objects via AA, (ii) laws, as causal relations between causal properties, "distinguish and identify properties as well" (Chakravartty, 2003, p. 394), (iii) "a disposition relates to its manifestation much as a possibility relates to the state that would hold were the possibility to become actuality. Such a state may be of various types: [I]t may or may not be something that is done by an object, and it may or may not be complex. Similarly, the manifestation of a disposition – the property that the object would possess were it to manifest the disposition – may be of various types. It may or may not be something that is done by the object, and it may or may not be complex. In particular, it may be the property of being *dissolved by water* (in the process sense or the end state sense), it may be the property of *being caused by flowers to sneeze*, of *being caused by an enclosed room to feel anxiety*. It may even be the property of *being washed* or of *being eaten*" (Vetter, 2014, p. 149), and (iv) "In fact, there is good reason to believe that often the manifestation processes are of such a complex nature. In short, where the conditional conception sees a stimulus/cause and a manifestation/effect, the possibility [or the ability] conception sees either a causally complex manifestation ... or else a manifestation plus a further fact about typical causes of that type of process" (Vetter, 2014, pp. 149-50).

in order to understand whether real, irreducible and ungrounded causal powers are indispensable in terms of making sense of scientific practice.

CHAPTER 5

CAN POWERS SAVE SCIENTIFIC PHENOMENA?

Nelson Goodman (1955) contends that “some of the things that seem to me unacceptable without explanation are powers or dispositions, angels, devils and classes” (p. 33). In other words, Goodman’s “philosophical conscience” simply could not tolerate dispositions, capacities or causal powers (Goodman, 1955, p. 33). Nevertheless, times have changed. Especially in the last twenty years, an increasing number of philosophers have abandoned the Humean accounts of laws, counterfactuals and causation in order to ontologically commit themselves to dispositionalism: It is either the notion that (i) all properties are dispositions (i.e., pandispositionalism); (ii) although some properties are categorical, the others are irreducibly dispositional (i.e., property dualism); or (iii) each property is both dispositional and categorical (i.e., the identity theory). A vexing question is: How is the widely-held empiricist stance leaving its place more and more to an archaic stance (i.e., Aristotelianism)?

One plausible answer to the above-mentioned question is that many contemporary metaphysicians’ intuitions have altered whereby they think that scientific practice should heavily influence our ontological commitments. Bird (2012), who is a pandispositionalist, contends as follows:

[O]ur metaphysics must be naturalistic to the extent that its purpose is to contribute to a coherent overall picture of the world, a major component of which is supplied by natural science. While metaphysics should not be enslaved to science, it is nonetheless true that harmony between a metaphysical view and the deliverances of science is a point in favor of that view. (Bird, 2012, p. 41)

Indeed, Bird’s (2012) contention is a concern for metametaphysics: Unlike analytic metaphysicians, contemporary naturalized metaphysicians think that we should do

metaphysics in light of the scientific achievements.¹⁰⁶ There is no doubt that evolutionary biology, general relativity and quantum mechanics, just to name a few, have all ignited philosophical discussions concerning mereology, the nature of time, modality and so on. Yet naturalized metaphysicians' presumption goes one step further: Science and metaphysics are intertwined. That is, scientific theories are suitable and applicable in terms of producing metaphysical knowledge (cf. Robus, 2015). These and the other related discussions belong to the metaphysics of science (MS). Soto (2015) articulates what the MS denotes thusly:

The MS investigates the *intertwining* of science and metaphysics, which takes place in various ways through the mutual contribution between these disciplines in view of their aims. Science can contribute to metaphysics by means of suggesting genuine metaphysical concerns and settling questions about the boundaries of empirical knowledge and reality. Likewise, metaphysics can contribute to scientific practice examining issues related to the elaboration of a scientific view of reality and looking into the sources and boundaries of scientific ontology. (Soto, 2015, p. 26)¹⁰⁷

Wartofsky (1967, p. 123) is among the first known metaphysicians who opines that the MS is a sub-discipline within the philosophy of science. In particular, according to Wartofsky (as cited in Soto, 2015), metaphysics is not only a heuristic for scientific practice, but also “it articulates the conceptual framework within which

¹⁰⁶Chakravartty (2013b) concurs with Bird (2012) thereupon: “The distinction between putatively acceptable naturalistic metaphysics and putatively excessive metaphysical inquiry [(i.e., analytic metaphysics)] does *not* concern *what* these forms of inquiry aims to do. Rather it concerns *how* these forms of inquiry go about achieving these aims. It is not in terms of general goals but rather in terms of precise methods that the distinction between naturalized metaphysics and some other brands of ostensibly worrying analytic metaphysics must be drawn” (p. 32). That is, a naturalized metaphysician's model of inquiry differs from that of an analytic metaphysician's: According to the former, science is the only guide for reaching metaphysical truth.

¹⁰⁷It is important to note that we do not try either to present the history of the MS or to answer the generic questions related to the MS in this chapter. For the historical waves of the MS, see Soto (2015, pp. 29-52). Moreover, Soto (2015) enumerates generic questions about the MS as follows: “Does scientific practice set certain restrictions on how to carry out metaphysical research, especially when it comes to the MS? What is the positive job that we expect the MS to accomplish? How can metaphysical theories genuinely contribute to the epistemic success of science? And, how can metaphysical theories be assessed – let alone subject to rigorous testing – in order to guarantee their positive epistemic contribution to scientific knowledge? Likewise, if metaphysics is somehow to be conceived of as complementary to science, is the MS possible only insofar as the current best scientific view of reality remains incomplete? And if that is so, do we have to assume that metaphysical assumptions currently involved in scientific theories are to be replaced or eliminated by new findings in future scientific research?” (p. 27).

science is possible” (p. 29). Chakravartty (2010, 2013b) agrees with Wartofsky (1967) regarding the notion that metaphysics makes science possible. Inevitably, the discussions pertaining to the MS also have to do with whether there are real, ungrounded and causally efficacious causal powers, dispositions or capacities, thereby we can distinguish causal laws from merely accidental regularities. Many naturalized metaphysicians (e.g., Bird (2007) and Chakravartty (2003, 2007)) think affirmatively.

In the next sub-heading, we will explicate Chakravartty’s (2010) argument first in order to decipher whether science is inevitably metaphysical.

5.1 Chakravartty’s maximalist approach

The maximalist approach is: “Metaphysics not only is a guide to or heuristic for science, but it also makes scientific research possible” (Soto, 2015, p. 34).

Chakravartty (2010) likewise argues that so long as the unobservables are included in the domains of natural sciences, science involves metaphysics. That is, science has a prominent a priori aspect whereby it explains observable phenomena by appealing to the unobservables. Chakravartty (2010) further articulates his stance as follows:

Prima facie, the sciences are plainly metaphysical, insofar as they appear to take a very strong interest in phenomena underlying the observable. The sciences routinely take an interest, apparently, in particles and fields and genes and enzymes and endless parade of entities that cannot be detected with the unaided senses. Wherever possible, hypotheses concerning these entities are subjected to empirical tests, but tests never render them *observable*, and some hypotheses are accepted for primarily explanatory reasons. As a consequence, in the attempt to rid scientific practices of the semblance of metaphysics, empiricisms are driven to extraordinary lengths. (Chakravartty, 2010, p. 64)

It can be inferred that Chakravartty (2010) contends that not only science is inevitably metaphysical, but also science is a priori to a certain degree (e.g., intuitions and the conceptual analysis) due to its investigation of the unobservables.

As for causal powers, Chakravartty (2013b) later contends that, like genes and enzymes, dispositions are indispensable in regard to the epistemology of science thereupon:

[S]cientific knowledge is often described as a knowledge of laws, concerning diverse categories of things found in the natural world. It is here that realism about dispositions can play an unificatory role, by facilitating a neatly integrated view of the concepts of causation, law, and kindhood. This affords scientific realism a high degree of economy in describing the metaphysical concepts central to its formulation and defence. (Chakravartty, 2013b, pp. 118-19)¹⁰⁸

Then what scientific instruments detect and measure are dispositions or causal powers after all according to Chakravartty (2013b, p. 117). Expressly, there are unobservable phenomena such as photons, dark matter and Higgs bosons that are detected and measured in the scientific landscape. Like causal powers, they are not detectable by means of the unaided senses. Should we simply assume, as we assume the existence of the unobservables of science, that causal powers as unobservable phenomena simply exist so that scientific knowledge can be interpreted properly?

Chakravartty (2010) answers affirmatively as follows:

I have suggested that certain metaphysical assumptions may be inescapable in the practice and interpretation of what we call science. Here is another example, to illustrate the present point: an acceptance of some conception of the uniformity of nature, many have suggested, may be a precondition for practices such as scientific generalization and prediction regarding empirical phenomena. But what more precisely this conception amounts to ... is something that cannot be determined except from the perspective of stances like metaphysics and empiricism. (Chakravartty, 2010, p. 74)

¹⁰⁸Chakravartty (2013b) illustrates his dispositional realist stance as follows: “In the context of scientific knowledge, causation is naturally theorized by dispositional realists [(e.g., Chakravartty (2007))] in terms of dispositions associated with properties of scientific interest. The properties of entities investigated in this context are *causal* properties: they confer dispositions for behaviour on the entities that have them. Why and how such things interact with one another, as well as with scientific instruments of detection and measurement? It is because they have certain properties that they behave in the ways revealed by scientific investigation. Masses, charges, accelerations, volumes, temperatures, and so on confer causal powers: dispositions to behave in certain ways when in the presence or absence of other properties. For example, the property of mass confers, *inter alia*, the disposition of a body to be accelerated when subject to a force. It is the ways in which entities with such properties are disposed to act, often in consort with others, that produce causal activity” (p. 117).

Chakravartty's (2010) maximalist argument concerning his realism of causal powers starts here: There would be no scientific practice without metaphysics. Chakravartty (2013b, 2017) continues to develop his position (i.e., realism about causal powers) in his later works nevertheless. It is important to note that, in his early work, Chakravartty (2010) does not expressly contend that what scientific instruments detect and measure are causal powers. Rather, Chakravartty (2010) contends that the unobservables of science (e.g. genes, Higgs bosons, photons, and so on) and the unobservables of metaphysics (e.g., *de re* necessities, capacities, dispositional properties, and so on) are categorically the same. That is, metaphysical speculation plays an ineliminable role in both of their characterization thus, it defines them.

Soto (2015) finds Chakravartty's (2010) argument highly problematic. In particular, Soto (2015) contends that: "[E]quating the unobservables of science with the unobservables of metaphysics seems to be gratuitous. Likewise, confounding the epistemic tools employed in metaphysical speculation with the epistemic tools employed in experimental and mathematical sciences is misleading" (p. 35).

I concur with Soto (2015, p. 35): We do not gain access to the unobservables of science by a priori metaphysical speculation. The unobservables of science are categorically different from those of metaphysics. Scientists perform numerous experiments involving, say, electrons, and the results of such experiments are highly consistent with the quantum electrodynamics model of electrons, which is currently the most prominent model of electrons. Of course, one day a model may be created, which would not involve electrons but still would be consistent with the experimental results. But, the impetus behind the counter-argument is that we can construct and manipulate the models that involve electrons, whereas causal powers are amenable to the conceptual analysis alone. Hence, Chakravartty (2010) fails to

show that science is inevitably metaphysical on the above-mentioned ground. Now, let us turn to Chakravartty's (2013b) later argument concerning his stance of naturalized metaphysics.

5.2 Chakravartty's naturalized metaphysics: Slippery slope

Chakravartty (as cited in Soto, 2015) further advances an argument as “the metaphysical slippery slope of science”, which is summed up along these lines: “[W]hen looking into philosophical problems resulting from the examination of science, philosophers are inescapably led to the postulation of metaphysical underpinnings of scientific theorizing” (p. 40). In particular, Chakravartty (2013b) opines that naturalized metaphysics differs from analytic metaphysics chiefly as follows:

Metaphysics generally ... proceeds by way of *a priori* stipulation and theorizing, and produces claims that are empirically untestable. Naturalized metaphysics, in virtue of its scientific starting point and context, is conceived as being susceptible and sensitive to empirical concerns. (Chakravartty, 2013b, pp. 32-33)

In light of these lines, metaphysical knowledge is akin to scientific knowledge: Metaphysical knowledge, if substantial, is in principle feeble in terms of consideration of new empirical evidence. In other words, like scientific knowledge, metaphysical knowledge is empirical too. However, analytic metaphysicians are after the sort of knowledge, which is “too far removed from the details of scientific investigation to yield anything worth at all. It is epistemically impotent, and thus a misguided philosophical pursuit” (Chakravartty, 2013b, p. 29).

However, in contrast to his position in his earlier work (i.e., Chakravartty (2010)), Chakravartty (as cited in Robus, 2015) is aware of the assumption he makes in virtue of which “this picture of naturalized metaphysics only works if we allow

‘the empirical’ and ‘the scientific’ to be conflated” (p. 6).¹⁰⁹ This is the naïve view of science, which is aptly described by Robus (2015) thusly:

[It] presupposes an easy and unproblematic distinction between observation and theory, so that theories are derived purely from empirical observations, which themselves have no a priori antecedents. But we have good reasons to reject such a presupposition. Kuhn famously argues that scientists working in periods of normal science already accept a priori metaphysical assumptions as part of the paradigm to which they belong. And, as Chakravartty points out, Kuhn’s is one of many accounts that articulate ‘the cognitive preconditions of scientific work ... that function to establish the very categories of objects, evidence, and inference that allow scientific questions to be posed and then investigated’ (Chakravartty 2013[b], p. 35). (Robus, 2015, pp. 6-7)

Indeed, there are a priori principles that are at work in natural sciences. In particular, natural sciences are not purely a posteriori endeavors. Theories, for instance, involve assumptions. Yet such principles make the project of naturalized metaphysics paradoxical in the first place by “eschewing a priori reasoning as a legitimate source of metaphysical theorizing, and by re-locating metaphysical legitimacy to the domain of science, the necessity of reasoning about a priori principles is reasserted” (Robus, 2015, pp. 7-8).¹¹⁰ At this point, Chakravartty (2013b) warns the reader that his version of naturalized metaphysics is not doomed to failure. Specifically, there are empirical contents pertaining to the scientific experimentation and theorizing, but not to the intuitive metaphysical contemplation.¹¹¹

¹⁰⁹Chakravartty (2013b) concedes that “there is a certain caricature of the sciences on which this conflation is benign” (p. 33).

¹¹⁰Robus (2015) articulates this grave problem of self-refutation as follows: “For once a priori principles are present in science a problem arises – how are we supposed to adjudicate disagreements between scientists about which a priori principle is better justified, or how to interpret any given principle? Such disagreements are immune to resolution on purely empirical grounds, and instead must rely, (at least in part) upon conceptual analysis and the trading of a priori intuitions and reasons. And *this* activity is precisely the sort of thing the naturalist wishes to rule out by naturalizing metaphysics in the first place!” (p. 7).

¹¹¹Chakravartty (2013b) presents his notion as follows: “Granting that scientific knowledge has a priori dimensions, it remains the case that the forms of inquiry we collect under the banner of the sciences are permeated with a posteriori content in virtue of the empirical concepts with which they are concerned. So why not take ‘naturalized metaphysics’ to label those metaphysical projects that are derived from, based on, inspired by, motivated by, constrained by, and grounded in this specifically empirical content, as opposed to scientific knowledge more generally?” (p. 42).

Then, according to Chakravartty (2013b), a naturalized metaphysician's amended project can be stated thereupon: Working one's way "through science piecemeal, examining it part by part, and partitioning out the *specifically empirical content* from those parts that are infected with a priori principles. It is this empirical content that will serve as the basis for naturalized metaphysical projects" (Robus, 2015, p. 9).

Nevertheless, this is not a fair amendment according to Chakravartty (2013b). Chakravartty (2013b) explains himself thusly: "The criterion of legitimacy suggested is far too easy to fulfil. Indeed, there is good reason to think that it is generally trivially satisfied, which would entail that every metaphysical project [(e.g., Parmenidean monism)] is an instance of naturalized metaphysics" (p. 42).¹¹² Hence, "if all metaphysical theories have a 'connection' to the empirical content of science, we must seek to articulate the superiority of naturalized metaphysical theories according to a different criterion" (Robus, 2015, p. 10). In pondering his stance, Chakravartty (2013b) re-emphasizes metaphysics' "proximity to the scientific context" (p. 33). After that, Chakravartty (2013b) initiates his final amendment through the grounding metaphor as follows:

There is a strong will here to distinguish cases in which, though it may never be possible to carry out an empirical test – for example to establish the one-way speed of light, or to detect the presence of hidden variables in quantum mechanics – it is nevertheless possible to understand what may be regarded as a priori commitments as appropriately linked to a posteriori content. This linking takes the form of some appropriate grounding in a system of empirical concepts, observations and so on. What is required, then, is some means by which to distinguish such work from work in non-naturalized metaphysics, which is perceived as being too preoccupied with epicycles on issues whose consideration takes place a very long distance from empirical investigation. (Chakravartty, 2013b, p. 43)

¹¹²In particular, Chakravartty (2013b) contends that the piecemeal approach might even lead to "Platonism['s derivation] from experience" (pp. 42-43).

The impetus behind the above-mentioned passage is that, in terms of proximity to scientific content, a priori commitments to, say, the one-way speed of light is not as distant to empirical content as commitments to, say, the existence of a spirit in the human. According to Chakravartty (2013b), such proximity can be deciphered in virtue of the two criteria: (i) “experiential distance” and (ii) “risk” (pp. 44-45). The former criterion concerns “the way in which [an object] is detected, if in fact it is detectable at all” (Chakravartty, 2013b, p. 44).¹¹³ As for the latter, risk concerns “how susceptible a hypothesis or a theory is to disconfirmation in light of the results of empirical work” (Chakravartty, 2013b, p. 45). The hypothesis that “There is a spirit in the human” is nearly a riskless hypothesis compared to the hypothesis “Given that there is an inertial frame of reference, $F = ma$ ”.

Robus (2015) argues that what is left to do for a naturalized metaphysician is as follows:

[Favoring] metaphysical hypotheses derivable from the empirical [is not promising], since every metaphysical hypothesis can be so derived. Instead, its task is to articulate the particular kinds of relations in which hypotheses can stand to the empirical content of science and favor those which stand in acceptably ‘close’ relations to this empirical content. (Robus, 2015, p. 11)¹¹⁴

Overall, what Chakravartty (2013b) shows is that there is an ineliminable metaphysical element in natural sciences. Chakravartty (2013b) does not go as far as

¹¹³Concerning experiential distance, Chakravartty (2013b) gives an example of his criterion thusly: “Tyson, the barking dog across the street in our otherwise quiet neighborhood, is directly detectable by me using my unaided senses. Proteins are less directly detectable; I would need to take a sample from Tyson and perform an assay in the lab to detect them. The possible worlds in which I now demonstrate this procedure to my friends and neighbors are not detectable at all” (pp. 44-45).

¹¹⁴In pondering a possible criticism against his argument, Chakravartty (2013b) adds thereupon: “Quite reasonably, one may ask: where do the speculations of metaphysicians of science typically fall on the spectra of experiential distance and risk described above? Undeniably, on reflection, it seems the answer to this question must be: not very close to empirical investigation! Typically, no matter how well informed by empirical details emanating from scientific work, our accounts of fundamental ontology in the sciences, or laws of nature, or the nature of time, and so on, do not fare especially well with respect to the metrics of experiential distance and risk” (pp. 46-47).

Mumford and Tugby (2013) do: The latter argue that metaphysics makes science possible.

Central to our discussion, Chakravartty (as cited in Soto, 2015) gives an example concerning the metaphysical speculation about “the causal powers involved in gene transcription processes as described by cell and tissue biology. In [Chakravartty’s (2013b)] view, *causal powers* would count as the metaphysical posits that help explain the working of scientific posits such as *genes*” (p. 41). Once again, such a speculation stems from the metaphysical slippery slope of science, Chakravartty (2013b) argues, thereby philosophers posit a metaphysical layer in order to give a thorough analysis of the scientific worldview. In a related manner, Soto (2015) interprets Chakravartty’s (2013b) slippery slope argument in regard to properties thereupon:

[M]etaphysical theorising goes beyond what we find in current best scientific theories; for instance, scientific theories refer to the mass, charge and spin of electrons, metaphysical theories add an extra [dimension] of theorising claiming that such mass, charge and spin can be conceived in terms of categorical properties, dispositional properties, or a mixture of them. (Soto, 2015, p. 42)

In responding to possible charges of underdetermination and theory-ladenness concerning the metaphysical theorizing, Armstrong (2012) contends that all the three accounts of properties mentioned above agree that “it is up to empirical science to tell us just what these universal properties and relations are” (p. 27). Later, Armstrong (2012) adds that “if there are more than two competing metaphysical theories, one should try, if possible, to indicate which theory one would retreat to if your view turned out to be incorrect” (p. 28).

As for the problems of Chakravartty’s (2013b) account of naturalized metaphysics, this thesis will not repeat Robus’s (2015, pp. 12-16) and Soto’s (2015, pp. 40-46) serious criticisms of Chakravartty’s (2013b) project in detail. In a

nutshell, Robus (2015) highlights the problem Chakravartty is faced with thusly:

“The empirical content of my experience *depends on* what scientific and metaphysical theories I accept, and those theories in turn cannot be determined by referencing some objective and theory-neutral content which all observers share” (p. 15). That is, according to Robus (2015, p. 15) agreeing on the cogency of a portion of the metaphysical theorizing by its closeness to empirical content is frivolous.¹¹⁵

As for Soto’s criticism, metaphysics cannot give scientific practice a direction: “In the present scenario [(i.e., Chakravartty (2013b))], it seems evident that philosophical speculation about the metaphysical underpinnings of science cannot decide what properties and laws there are” (Soto, 2015, p. 43). Now, let us turn to the counter-arguments against Chakravartty (2013b), which are peculiar to this thesis.

5.2.1 Woes and amendments

First, Chakravartty (2013b) contends that if one is ontologically committed to, say, genes and protons in terms of scientific explanation, she is also committed to the related metaphysical underpinnings such as *de re* modalities and dispositions.

Expressly, Chakravartty (2013b) contends as follows:

Indeed, philosophical defences of the reasonableness of believing in the sorts of scientific entities and processes that are *not* generally considered metaphysical today, such as genes and gene transcriptions, often make recourse to views about things that *are* regarded as falling under the purview of metaphysics, such as causation, modality and so on. (Chakravartty, 2013b, p. 28)

Beta decay (β -decay) and transcription, as well as protein formation, “are not generally considered metaphysical today” (cf. Chakravartty, 2013b, p. 28). Such

¹¹⁵Robus (2015) concludes his counter-argument against Chakravartty’s (2013b) amended naturalized metaphysics as follows: “What I’ve argued for here is that a picture of science where such a piecemeal process is possible – where there is an unproblematic and objective partition in the parts of science which are infected with a priori commitments, and those which are not – is as much of a myth the naïve picture of science Chakravartty saw fit to reject” (p. 16).

processes are not metaphysical because although they are causally complex, they are part of scientific practice. On the web page of *Encyclopedia Britannica*, “Beta decay” is defined as follows: “Positron emission first *observed* [emphasis added] by Irène and Frédéric Joliot-Curie in 1934” (Encyclopedia Britannica, n.d.).¹¹⁶ It is rightly observed, modelled and manipulated whereby we can construct and use the positron emission tomography (PET) technology in order to diagnose, say, thyroid incidentaloma. What is more, by means of the variable energy positron beam (VEP), scientists “measure the annihilation (gamma) radiation of a positron-electron annihilation event (511 [kiloelectron volts])” by determining “defect depth distributions and [characterizing] open volume defects in sub-surface regions, in thin films and at interfaces by means of Doppler Broadening and positron (back)diffusion measurements” (VEP, n.d.).¹¹⁷ Unlike, say, dispositions, such entities and their related processes are not after physics. Indeed, they are not observed with the unaided senses, but they are manipulatable. That is, they can be construed as the variables of scientific experiments (e.g., electrons in the Davisson-Germer experiment).

Second, regarding the demarcation of naturalized and analytic metaphysics, Chakravartty (2013b) argues thusly:

[N]on-naturalized, untethered metaphysics produces results – theories of universals, substances, bundles, necessities, possible worlds, and so on) that are not conceived as being answerable in any way to empirical investigation. In contrast, naturalized metaphysics, in virtue of its scientific starting point and context, is conceived as being susceptible and sensitive to empirical concerns. The suggested distinction between naturalized and non-naturalized metaphysics just rehearsed turns on the idea that the former and not the latter

¹¹⁶Beta decay. (n.d.) In *Encyclopaedia Britannica*. Retrieved from <https://www.britannica.com/science/beta-decay>.

¹¹⁷The Faculty of Applied Sciences of TU Delft. (n.d.). *The Variable energy positron beam (VEP)*. Retrieved from <https://www.tudelft.nl/en/faculty-of-applied-sciences/about-faculty/departments/radiation-science-technology/neutron-positron-methods-for-materials/research-facilities/positron-facilities/the-variable-energy-positron-beam/>.

is sufficiently connected, *in some way* [emphasis added], to empirical findings. (Chakravartty, 2013b, p. 33)

Two points are important here: (i) naturalized metaphysics' results are answerable to empirical investigation (cf. Chakravartty, 2013b, p. 33) and (ii) naturalized metaphysicians, in some way, consider empirical findings when they theorize (cf. Chakravartty, 2013b, p. 33). Chakravartty (2007, pp. 13-15) has already pondered how one should categorize scientific phenomena, to which scientific claims refer, as is depicted in Table 2:

Table 2. Scientific Phenomena to Which Scientific Claims Refer

(a) Scientific phenomena that can be observed with the unaided senses.	(b) Scientific phenomena that cannot be observed with the unaided senses.
-	(b ₁) Scientific phenomena that are not observable, but detectable.
-	(b ₂) Scientific phenomena that are neither observable nor detectable, but explanatorily useful.

Note: This table is adapted from *A metaphysics for scientific realism: Knowing the unobservable*. (p. 15), by A. Chakravartty, 2007, Cambridge, England: Cambridge University Press.

According to Chakravartty (2013b), causal powers as first-order properties, as well as *de re* necessities, are causally detectable because of their causal efficacy. Thus, such entities and processes belong to (b₁). Causal powers result in *de re* necessities, which in turn in laws, thereby such powers are explanatorily significant.

However, those metaphysical underpinnings are not detectable in the first place. Conflating the unobservables of sciences with the unobservables of metaphysics is a category mistake: The former is conducive to the scientific methodology, whereas the latter is conducive to the conceptual analysis alone. Subsequently, the latter can merely be a heuristic device in regard to scientific practice. Electric charge, for example, is categorically different from capacities or

dispositions, which are causal powers, because the former, unlike the latter, is manipulatable whereby it can be expressed through mathematical formulas.

Asserting that electric charge is itself (or has) a dispositional property or a causal power is merely story-telling, which may or may not be illuminating, about scientific phenomena. Causal powers are heuristic devices at best.

Third, despite Chakravartty (2013b)'s reluctance, Chakravartty (2007) gives an example regarding how powers can save scientific phenomena thusly:

If, in future, empirical tests were designed for the presence of hidden variables, though today this seems the stuff of science fiction, they would be shaped by these early findings. Semirealism neither is too impatient to seek the truth in Newton's theory of gravity or QM [(i.e., quantum mechanics)], simply because they contain elements one cannot explain in realist terms, nor eschews an interest in deeper questions. Realists should believe in the things for which they have warrant, and let the sciences get on with investigating the rest. (Chakravartty, 2007, p. 69)

That is, according to Chakravartty (2007), if "we seek the truth in Newton's theory of gravity", what we will eventually find is dispositions, capacities or causal powers. Thus, such powers are real and detectable after all. Indeed, he acknowledges that, today, such metaphysical entities are considered as the "stuff of science fiction" (p. 69). Yet Chakravartty (2007) argues that in the future dispositions may have the upper hand in terms of understanding scientific phenomena.

I prefer to interpret what the history of science expresses differently than Chakravartty (2007) does: There may be an objective causal structure inherent in the world, but the re-introduction of Aristotelian powers into the scientific landscape necessarily requires a paradigm change. However, the world may have an inherent causal structure today as it may have, say, two thousand years ago. Thus, no paradigm change is necessarily needed. Subsequently, if there is such a structure, then we all can agree on what laws of nature are and why they exist. That is, there would be no need for causal powers even as a heuristic device.

For simplicity's sake, unlike Chakravartty (2013b), this thesis endorses the alternative of objective causal structures alone. Now, let us turn to Chakravartty's (2017) latest response to the critics who think that powers cannot save scientific phenomena.

5.3 Chakravartty's latest amendment of causal powers

Unexpectedly, Chakravartty (2017) starts his article by acknowledging that the existence of irreducible causal powers is not entailed by taking scientific practice seriously. Nevertheless, there are some philosophers (e.g., Chakravartty (2007)) who think otherwise. Chakravartty (2017) elucidates this point thusly:

Some [(e.g., Cartwright (1989); Ellis (2001); Bird (2007); Chakravartty (2007))] have ... sought to explicate the concept of law by appealing to metaphysical facts underlying fickle regularities. These deeper metaphysical facts putatively concern dispositions possessed by things in the world, which may then figure in explanations of why these things behave in certain conditions, and why they do not when conditions are varied in certain ways. (Chakravartty, 2017, pp. 24-25)¹¹⁸

Chakravartty (2017) contends that, in the literature, we generally come across the two families of the scientific practice-based arguments for the existence of causal powers or dispositions: (i) "arguments from scientific explanation" and (ii) "arguments from scientific abstraction" (pp. 29-32). It is important to note that, in addition, there are generic arguments for the dispositional realism, according to which the dispositional realism is an epistemological virtue because "one's ability to explain certain facts about the world is significantly enhanced by adding dispositions to one's ontology" (Chakravartty, 2017, p. 29).¹¹⁹ As is already argued in this

¹¹⁸Chakravartty (2017) then adds: "[D]ispositional realism is here viewed as a commitment that is entailed or strongly suggested by the ways in which scientific knowledge is employed by the scientists in the course of scientific, as opposed to philosophical work" (p. 25).

¹¹⁹Chakravartty (2017) exemplifies this notion thereupon: "[W]hy do objects ... behave in law-like or regular ways in similar circumstances? Answer: [T]hey are disposed to do so, in virtue of their

chapter, Chakravartty (2017) is aware of this argument's apparent contestability: "On the commonly invoked Humean view ... there is no *want* or *need* for an explanation of law-like [*sic*] regularities" (p. 29). Hence, such arguments for the dispositional realism are not convincing.

The former argument-type is twofold according to Chakravartty (2017): (i) "the dispositional regress argument" and (ii) "the dispositional exercise argument" (pp. 29-31). We are only interested in (ii), which is championed by Cartwright (2009). The argument goes as follows: "[I]n order to explain what is happening in [composite phenomena], one must appeal to the existence of dispositions, which are the only sorts of properties capable of producing this interesting behaviour of exercising without manifesting" (Chakravartty, 2017, p. 30).¹²⁰ There is no need for a further explication of Cartwright's position since we have already done so in the third chapter. Chakravartty (2017) expresses one general worry about Cartwright's (2009) argument's inability to establish the existence of causal powers: "[T]he explanatory context in which one cites dispositions exercising in the absence of their characteristic manifestations does not even arise for the antirealist. Such a person is content with a Humean description of the phenomena" (p. 30). Overall, the arguments from scientific explanation "do not establish any further grounds for belief in dispositional properties than the traditional arguments they are intended to supplement" (Chakravartty, 2017, p. 30).

dispositional properties; these causal powers thus explanatorily ground law-like [*sic*] regularities" (p. 29).

¹²⁰In order to explain what "composite phenomena" connotes, Chakravartty (2017) cites Cartwright's (2009, pp. 151-55) example thusly: "[I]magine two negatively charged particles whose gravitational attraction is exactly balanced by their Coulomb repulsion. Here we have a composite phenomenon, combining both gravitational and electrostatic forces. In this case, one might reasonably say that both the disposition for attraction associated with the gravitational force and the disposition for repulsion associated with the electrostatic force are exercised, even though, as a consequence of the fact that the two forces are equal and opposite there is no manifest motion" (p. 30).

As for the latter, according to Chakravartty (2017), the arguments from scientific abstraction are transcendental whereby “the efficacy of abstraction in scientific practice would be inconceivable, if in fact there were no dispositions” (p. 31).¹²¹ The impetus behind this argument is that there are regular behaviours if and only if there are occurrent dispositions.¹²² Chakravartty (2017) rephrases Cartwright’s (2009) crucial insight as follows:

[T]he ability to plan our endeavours, make predictions, manipulate phenomena, and consequently, to make good policy decisions of great importance to ourselves and our environment, depends on the presupposition that we have knowledge of [causal powers]. (Chakravartty, 2017, p. 32)

Instead of expressing Chakravartty’s (2017, pp. 32-33) counter-arguments against this argument, one may argue that Cartwright (2009) simply puts the cart before the horse. That is, instead of establishing the existence of causal powers independently, Cartwright (2009) simply assumes that there are such powers whereby there are regularities, which in turn refer to causal powers. Nevertheless, our world with categorical properties alone would be as orderly as it currently is even if causal powers did not exist.

Now, let us turn to a new family of coherence-based argument proposed by Chakravartty (2017), which tries to show why causal powers are ontologically significant, irrespective of scientific practice.

¹²¹“Abstraction” connotes extracting “certain features of a target system of interest in the world and build only these features into a model of that system, ignoring others that may be relevant to its behaviour” (Chakravartty, 2017, p. 30).

¹²²Such insights are initiated by Cartwright (1989), then developed by Hütteman (1998). Chakravartty (2017) summarizes their argument aptly: “[P]hysical laws are generally abstract and thus only describe behaviours of isolated systems. It is common scientific practice nonetheless ... to apply such laws to non-isolated systems, and it would be impossible explain this practice unless both sorts of systems have dispositions” (p. 31).

5.3.1 Chakravartty's property identity argument

Chakravartty (2017) starts his discussion optimistically: “Even though I suspect that, ultimately, at the level of fundamental intuitions, there may be an irresolvable impasse between the dispositional realist and antirealist in connection with the usual, metaphysical arguments for and against dispositions” (p. 33), there still is a route, Chakravartty (2017) continues, from science to entity realism (i.e., realism about dispositions). What kind of properties does science study? What is it that makes, say, “mass” the property it is? Chakravartty (2017), more or less similar to Shoemaker (1980) and Swoyer (1982), contends that properties are identical to their causal powers. On Chakravartty's (2017) view, “it is dispositions that constitute property identity; one may thus call it a dispositional essentialist view of property identity” (p. 33). Chakravartty (2017) then elucidates his notion with an example as follows:

If entities having negative charge are disposed to repel other entities with negative charge, and to attract entities with positive charge, then these dispositions are part of the nature of charge – they constitute (in part, since negative charge is also associated with other dispositions) the identity of charge. (Chakravartty, 2017, p.33)

Of course, Chakravartty (2017) is aware of the several counterintuitive metaphysical implications resulting from his ontological commitment to dispositions. One of them is that given that properties have dispositional essences alone: (i) there would be dispositional properties alone and (ii) laws of nature would be metaphysically necessary. These consequences conflict with the common philosophical intuition.

Nonetheless, Chakravartty (2017) raises an intriguing question, which may be puzzling to dispositional antirealists: “If one rejects dispositional essentialism, how is one to understand the identities of properties instead?” (p. 33). This question may not be difficult to answer after all. Armstrong (as cited in Choi & Fara, 2012), who is a dispositional antirealist, subscribes to *quidditism*, according to which “the essence of

a property is constituted by its internal or self-contained nature, that is, what is called *quiddity*, that is only contingently related to the specific theoretical roles it plays”.¹²³

For example, “negative charge is something that is ultimately unknowable – its identity is primitive; there is nothing more that can be said about it” (Chakravartty, 2017, p. 33). According to Chakravartty (2017), although there is no non-question begging way “to resolve the dispute between the dispositional essentialist and the dispositional antirealist about the property identity” (p. 33), Chakravartty (2017) admits that “from a scientific perspective, the rejection of dispositional essentialism and the adoption of quiddities seems a bizarre way to make sense of our ordinary talk of properties, let alone property talk in scientific domain” (p. 33). Overall, Chakravartty (2017) contends that the dispositional realism has the upper hand over the dispositional antirealism because quidditism, which denies the mind-independence of dispositions, goes against the scientific spirit thusly:

[A dispositional antirealist] may persist in claiming that what makes a property the property that it is, is something primitive. But is it not the very aim of sciences to tell us about what the natural world is like? This, I will now contend, generates a kind of pragmatic incoherence on the part of the dispositional antirealist in the context of the sciences. (Chakravartty, 2017, p. 33)

The dispositional antirealism, which is an empiricist position, according to Chakravartty (2017), “is driven to the [notion] that the natures of properties investigated by the sciences are entirely unempirical!” (p. 33) Thus, one might say that, in regard to Chakravartty’s (2017) view, it is oxymoronic to employ “empiricism” and “quidditism” in the same sentence affirmatively. Nonetheless, an empiricist, Chakravartty (2017) expresses, is not doomed to self-refutation; there is

¹²³Choi, S. & Fara, M. (2012). Dispositions. *The Stanford encyclopedia of philosophy*. Retrieved April 15, 2018, from <http://plato.stanford.edu>. According to Armstrong (1997a), “properties are self-contained things, keeping themselves to themselves, not pointing beyond themselves to further effects brought about in virtue of such properties” (p. 80).

another way for an empiricist to talk about the natures of properties: “[Saying] nothing at all about property identity” (p. 34). Yet according to Chakravartty (2017), “this sort of quietism also seems deeply anti-scientistic. It does not sit well with the idea of championing an empirical approach to understanding nature either” (p. 34).

Chakravartty (2017) concludes his argument by contending that the dispositional realism is the only position for a scientific-minded philosopher of science to subscribe. In other words, in order to make sense of the property identity coherently and to avoid pragmatic incoherence, there is no alternative left for a philosopher of science to be a dispositional realist: “[I]f what makes [natural] properties ... has something to do with their causal powers or dispositions, then the natures of properties of scientific interest are things that can be investigated by the sciences after all” (Chakravartty, 2017, p. 35).

Last, Chakravartty (2017) is content that he has achieved his aim by showing that causal powers can save scientific phenomena in terms of the property identity thereupon:

I have sketched one such demonstration: the natural defence paid by empiricists to the sciences as the paradigm of inquiry into the natural world undermines their natural antipathy towards the notion of a disposition. This contention is infused with irony: the traditional empiricist worry is that dispositions are mysterious or occult, but in the context of property identity, it appears that one must value dispositions *for being empirically accessible instead* [emphasis added]. It is in this way that a scientific principle ... comes to undermine dispositional antirealism in the scientific domain. Thus, it seems that powers can do some valuable work in saving the scientific phenomena after all. (Chakravartty, 2017, pp. 35-36)

In order to decide whether Chakravartty’s (2017) position, as is caricatured in the above-mentioned passage, is convincing, let us turn to the explication of Chakravartty’s (2017) argument and then determine whether its virtues outweigh its woes.

5.3.1.1 Woes and amendments

First, although he argues otherwise, Chakravartty (2017) still adheres to the results of scientific practice in order to show that “powers can do some valuable work in saving scientific phenomena” (p. 36). In particular, according to Chakravartty (2017), an empiricist will be the victim of an irony, if she worries that “dispositions are mysterious or occult” (p. 35). The reason is that, “in the context of property identity”, she “must value dispositions *for being empirically accessible instead*” (Chakravartty, 2017, p. 35). On a related note, Cartwright’s prominence appears at this very point. Expressly, although Cartwright (1999) classifies herself as an empiricist-minded philosopher, she is, like Chakravartty (2007), ontologically committed to causal powers or capacities. As noted, both Cartwright (1989, 1999) and Chakravartty (2007) contend that what sciences ultimately investigate, detect and measure are causal powers.

However, their fundamental problem is that, up to now, there has been no record of a causal power, which is supposed to be empirically detectable. Without the phrase “in the context of property identity”, Chakravartty (2017, p. 35) still commits a category mistake by conflating the unobservables of science and the unobservables of metaphysics. Nevertheless, even with the phrase, it is still debatable whether there is more to the property identity apart from the molecular structures or the geometry of molecules of properties. Chakravartty’s (2017) amendment is to include the clause “in the context of property identity” (p. 35) in his argument whereby it can be possible to ward off the earlier counter-arguments.

In fact, the nature of an electron, for example, is indeed a matter of ongoing empirical investigation, which does not adhere to causal powers: According to Qiu-Hong Hu (2004), “the topological structure of the electron is a closed two-turn helix

(a so-called Hubius Helix) that is generated by circulatory motion of a mass-less particle at the speed of light” (Abstract). As for DNA, its nature has been investigated by, say, histochemical and physical techniques. No modally laden properties have been invoked yet. We hitherto know what electrons and DNA molecules are, and we do not confuse them with one another, despite the absence of causal powers. Notwithstanding, let us examine next whether Chakravartty (2017) succeeds through his coherence-based property identity argument.

Second, according to Chakravartty (2017), “it is dispositions that constitute property identity; one may thus call it a dispositional essentialist view of property identity” (p. 33). This seems to be a topic of mereology. At this point, in order to understand Chakravartty’s (2017) contention fully, let us follow Psillos (2014), according to whom there is a need to “refer briefly to the issue of constitution vs. identity” (p. 19) concerning regularities. Specifically, following Baker (2007), Psillos (2014) contends that constitution is not identity: “[E]ntities are individuated by their persistence conditions; hence though an entity R might well be constituted by entities S, it is not identical with their sum, if R has different persistence conditions than the sum of these entities S” (p. 19).¹²⁴ On Baker’s (2007) view, “constitution is a relation of unity – unity *without* [emphasis added] identity” (p. 32).

It is important to note that “even though it is right to say that if X is constituted by the sum of entities Y, X is not identical to this sum, it is also right to *add* that sums are ‘the ultimate constituents’” (Psillos, 2014, p. 19). That is, “an entity X might be constituted by the sum of entities Y, and yet commitment to X is a

¹²⁴Psillos (2014) illustrates this thought through an example: “A flag is constituted by its molecules, but it is not identical with (the sum of) them; the two entities have different persistence conditions. A war-battered flag is still the flag that it was even though plenty of its initial molecules of a different kind are in it” (p. 19).

further commitment than *simply* to the mereological sum of its parts” (Psillos, 2014, p. 19). What is this “further commitment”?

Following Johansson (1998), Psillos (2014) points out a way “to reconcile mereology with ontological novelty” thusly:

Mereology is based on the notion of proper part (‘Y is proper part of X’) and this notion is governed by three axioms: it is irreflexive, asymmetric and transitive. There is a principle called ‘weak supplementation’ (WS) according to which: *if a whole has a proper part, it has also another proper part that is disjoint from the first* [emphasis added]. If we want to preserve the idea that constitution is compatible with ontic novelty, we need to explore the intuition that, occasionally at least, the whole is more than the sum of its constituent parts. (Psillos, 2014, p. 20)

Psillos’s (2014) interpretation of ontological novelty concerns regularities, not causal powers. However, there seems to be no methodological incoherence about the application of the same thought to Chakravartty’s (2017) notion of causal powers. Such causal powers adhere to the part-whole relations after all. According to Psillos (2014, p. 21), the further commitments concern the WS whereby ontic novelty is grounded.¹²⁵ Psillos (2014, p. 21) concludes his argument accordingly: A regularity is the mereological sum of its parts and the unity of a pattern.

What about the identity of a causal power or a dispositional property? Unfortunately, Chakravartty (2017) does not expressly state what he understands by “identity”. That is, what are the conditions of the property identity? Chakravartty does not give an explicit answer. Despite such an omission, Chakravartty’s (2017) example gives us a hint concerning his notion of identity: The identity of charge is constituted by the dispositions it confers. That seems to be the end of story about the

¹²⁵Indeed, Psillos (2014) sums up his thought thusly: “A regularity is the *mereological sum* of its parts and yet it is more than the sum (in the colloquial sense) of its spatio-temporal constituents (that is, its instances). Call S the totality of the instances (spatio-temporal parts) of the regularity. S is a proper part of R and yet (according to the [WS]) there is another proper part R which is not a spatial constituent of R. Call this P. Hence, $R = S + P$. What is this further proper part P? I claim: The *pattern* that unifies the regularity” (p. 21). We will briefly mention Psillos’s notion of natural patterns in the sixth chapter.

property identity according to Chakravartty (2017). Yet, as is shown, constitution is not identity per se. That is, even if the causal powers constitute a property as their ultimate constituents, unless their persistence conditions are the same, it will not be sufficient for that property to be identical with its powers (cf. Psillos, 2014, pp. 20-21). Unless the above-mentioned conditions are met, a property will not just be the mereological sum of its dispositions or causal powers.

Then there are two options left for Chakravartty (2017): (i) denying the statement “Entities are individuated by their persistence conditions” or (ii) dispensing with the reconciliation of mereology with ontic novelty – so that the whole would be equal to the sum of its parts. Neither the former nor the latter option looks promising.¹²⁶ In addition to its causal powers, it is likely that there is some indeterminate constituent part, which makes a property the property it is. Overall, Chakravartty’s (2017) property identity argument is in need of further explication, mainly in terms of his notion of identity, in order to be a promising amendment regarding why causal powers are indispensable.

Third, in order to avoid pragmatic incoherence in the context of natural sciences, according to Chakravartty (2017), an empiricist, who is taken to be a dispositional antirealist, should take off her antirealist glasses, and embrace causal powers or dispositions because “if what makes properties like charge ... the [property] that [it is] has something to do with causal powers ... then the natures of properties of scientific interest are things that can be investigated by the sciences after all” (p. 35).

¹²⁶By taking regularities as his paradigm, Psillos (2014), concerning the persistence condition, states that “regularity persists even when some of its instances cease to exist, or even if there were more instances” (p. 19); concerning ontic novelty, Psillos (2014) adds that “the regularity would have persisted even if some its actual instances had not existed” (p. 19).

Now, we return to the topic of property identity. According to Chakravartty (2017), it is an unscientific attitude to try not to answer the question: “Why is an electron the property it is?” That is, if a scientist does not try to answer that questions of the property identity, then she will be subject to pragmatic incoherence.

There are theoretical physicists, as well as practicing scientists, including Feynman (1967), who beg to differ. In particular, naturalized metaphysics cannot offer any help to a scientist concerning the property identity because nearly all scientists are not interested in pondering the property identity; it is simply an issue of ontology. Thus, there is no pragmatic incoherence. On this topic, Feynman (1967), whose assertion is pragmatically warranted, contends as follows:

In order to figure out what an atom is going to do in a given situation we make up rules with marks on paper, carry them into a machine which has switches that open and close in some complicated way, and the result will tell us what the atom is going to do! If the way these switches open and close were some kind of model of the atom, if we thought the atom had switches in it, then I would say that I understood more or less what is going on. I find it quite amazing that it is possible to predict that what will happen by mathematics, which is simply following rules which really have nothing to do with what is going on in the original thing. (Feynman, 1967, pp. 170-71)

What is an atom? It is many things: (i) it is a fundamental piece of matter; (ii) it is made up of protons, electrons and neutrons; and (iii) it is kept together because “[t]he negative electrons are attracted to the positive nucleus by the same electrical force” (Propulsion, n.d.).¹²⁷ An atom is what it is because of its proper parts (i.e., its geometry of protons, electrons and neutrons) and the laws it participates in (e.g., Coulomb’s law). In fact, we know atoms very well, thereby we can “predict that what will happen by [mathematical equations that express laws]” (Feynman, 1967, p. 171). In terms of a scientific framework, according to Feynman (1967), that seems to be the whole story about what an atom is.

¹²⁷Propulsion. (n.d.). Retrieved from <http://www.qrg.northwestern.edu/projects/vss/docs/propulsion/1-what-is-an-atom.html>.

Unless the framework is determined, we would continue to ask none the less why an atom is the sum of its proper parts and the laws. Feynman (1967) argues that such questions are raised due to the problem of indeterminate scientific framework thus, they are unscientific:

What is it about nature that let this happen, that it is possible to guess from one part what the rest is going to do? That is an unscientific question: I do not how to answer it, and therefore I am going to give an unscientific answer. I think it is because nature has a simplicity and therefore a great beauty. (Feynman, 1967, p. 173)

Indeed, we can give unscientific answers to unscientific questions, as Feynman (1967), Cartwright (1999, 2009) and Chakravartty (2017) did. One serious problem is to conflate unscientific questions with the scientific ones, in turn unscientific answers with the scientific ones. Both Cartwright (1999) and Chakravartty (2007) seem to subscribe to such an ungrounded conflation. Causal powers can be a heuristic device, but “an ontologically thick conception of powers is not the direct consequence of the foregoing ordinary way to accommodate talk about powers in everyday life and in science. Rather, [it] is a metaphysical *theory* about powers and their nature” (Psillos, 2014, pp. 12-13).

As noted, instead of assuming, Chakravartty (2017) should have established that the property identity is constitution and then he should have argued that, say, a charge is identical to its causal powers or dispositions. If he did establish that, then he would have given us a promising metaphysical argument. However, Chakravartty (2017) did not give a metaphysical a priori justification of the property identity as constitution, let alone a scientifically-oriented one.

Overall, quietism about the property identity does not beget “pragmatic incoherence in the context of the sciences” (p. 34), as Chakravartty (2017) states, because the issue of the property identity is not included in that context. Mereology,

time and laws of nature, for example, might ultimately be causally complex processes. Nonetheless, the metaphysical theories about them belong to a different category than to the one that the scientific theories belong. In the end, neither Chakravartty (2017) nor Cartwright (2009) shows that causal powers can save scientific phenomena.

Now, let us proceed to the next and the last chapter in order to give concluding remarks concerning in which direction a Humean and a non-Humean should further current knowledge about laws of nature.

CHAPTER 6

CONCLUDING REMARKS

This thesis has explicated four different accounts of laws of nature: (i) the MRL account of laws, (ii) the ADT account of laws, (iii) scientific dispositional essentialism of laws and (iv) Cartwright's (1989, 1999) capacity account of laws. Excluding the first account, all the accounts are non-Humean. So far, leaving methodological issues aside, we have focused only on the metaphysics of laws whereby the accounts are categorized as Humean and non-Humean. Nevertheless, no account is problem-free. Following Psillos (2002), let us attempt "a brief cost-benefit analysis" (p. 210) of the above-mentioned accounts.

6.1 Laws revisited

As for the MRL account, let us enumerate the benefits first:

- Its metaphysics is unproblematic: laws are regularities.
- Its epistemology is clear: laws can be known by the ordinary inductive methods.
- It shows how facts about laws supervene on non-nomic facts.
- It is close to scientific practice, that is, to what scientists take laws to be.
- It is able to deflect some of the most serious objections levelled against the Humean approach to laws: it shows that there is a robust, if not entirely objective, distinction between laws and accidents; it can accommodate the existence of uninstantiated laws; it can show, to some extent, at least, how laws can support counterfactuals; it shows that what regularities constitute laws is not just a reflection of our subjective or epistemic preferences. (Psillos, 2002, p. 210)

The costs are as follows:

- It seems to deprive laws of some, intuitively clear, sense of necessity.
- It does leave a residual quasi-subjective element to the characterization of lawlikeness. (Psillos, 2002, p. 210)

Now, let us turn to the ADT view. First, its benefits are expressed below:

- It shows how laws are relations among properties.

- It makes lawhood entirely objective.
- It shows how uninstantiated laws can be accepted
- It issues in an *objective* distinction between laws and accidents
- It shows how laws can support counterfactuals. (Psillos, 2002, p. 211)

Its costs are as follows:

- Its metaphysics is problematic; the notion of necessitation remains unclear.
- Its epistemology is legitimate, since it is based on inference to the best explanation. Yet it is not clear that positing necessitating relation among universals is indeed the best explanation of lawhood.
- It's not in contact with the concept of a law of nature, as this is used in science.
- By denying that nomic facts supervene on non-nomic facts, it makes a mystery of how laws issue in regularities. (Psillos, 2002, p. 211)

As Psillos (2002) contends, it is misleading to attempt a single cost-benefit analysis of (iii). One important reason is that, as is shown, scientific dispositional essentialists (e.g., Ellis (2001); Bird (2007); Chakravartty (2007)) differ from one another in terms of their own views of the metaphysics or the epistemology of laws, as well as of properties. Thus, “the scientific dispositional essentialist account of laws”, to which a brief cost-benefit analysis does not apply unequivocally, is an empty concept.

What all dispositional essentialists, unlike Humeans, agree on is that whether irreducible and ungrounded or not, there are causal powers. Let us repeat what difference causal powers could make concerning the metaphysics and the epistemology of laws: Irrespective of their reducibility or grounding, such powers, as the lawlike regularity enforcers, could try to solve the vexing problems of identification without being subject to the problem of inference. On the other end, if causal powers were reducible, then ontological commitment to them would not be needed; if not, then (iii), in general, would be the most metaphysically weighty and the least scientific account of laws.

The problems that challenge (iii) also challenges (iv). What is more, if Cartwright's (1989, 1999) account is considered in its original version, then the benefits of (iii) will not apply to (iv), because Cartwright (1989, 1999) is hesitant to give a conceptual analysis of capacities. This thesis, in the fourth chapter, has attempted to give such an analysis. Even in its amended versions, Cartwright's newly proposed metaphysics of laws are not problem-free either. As is stated, Cartwright (1989, 1999) starts her philosophical journey as an entity realist and concludes it as a superrealist. In particular, Cartwright (1989, 1999) first argues that scientific practice has shown there are no fundamental laws, then she subscribes to fundamentalism concerning capacities. In the end, it is left to the reader to decide whether Cartwright (1989, 1999) is a certain kind of dispositional essentialist of laws and properties after all. (vi) is, both in its original and amended versions, at least, as metaphysically weighty as (iii) is.

Overall, in regard to the road-map of this thesis, the metaphysical theories of scientific dispositional essentialists and that of Cartwright (1999) are the least preferred alternatives to subscribe in terms of furthering our current knowledge about laws. Our analysis shows that (i) gains the upper hand over (ii). Despite not being problem-free, for now, the most preferred alternative seems to be the Humean way (i.e., (i)). Next, let us turn to what Humeans and non-Humeans should attempt in order to further our understanding of laws.

6.2 New directions for Humeans and non-Humeans

I see no way forward for the non-Humeans unless they dispense with their ontological commitment to causal powers. This thesis' primary focus is on how to make sense of Cartwright's notion of capacities. As is discussed in depth, any

alternative metaphysical theory, which adheres to real, irreducible and ungrounded causal powers in order to explain the nature of capacities, including CPIT or DIT, is deeply problematic. Cartwright (1989, 1999) employs a double standard. In particular, although Cartwright (1989, 1999) contends that fundamental laws do not exist, she is a fundamentalist about capacities, to which she is reluctant to give a metaphysical theory. That is, instead of justifying capacities a priori or a posteriori, Cartwright (1989, 1999) simply assumes that capacities exist. Cartwright (1989, 1999) appeals to capacities due to their epistemological virtues. The world may not be as dappled as Cartwright (1999) thinks it is after all.

Giere (2008) suggests that Cartwright should dispense with capacities completely. According to Giere (2008, p. 129), Aristotelian natures or causal powers are epistemologically powerless tools in terms of explaining scientific phenomena, as the history of science has already showed. In particular, Giere (2008) contends as follows:

In spite of my considerable sympathies with Cartwright's program, I still find her invocation of capacities and natures to be anachronistic, even quixotic. I still feel there was something profoundly correct about the rejection of such notions that was part of the scientific revolution of the seventeenth century. (Giere, 2008, p. 129)

It is important to note that Giere (2008) warns the reader that he, like Cartwright (1989, 1999), still finds the empiricist account of laws deeply problematic. Nevertheless, Giere (2008) adds that "rejection of the arid metaphysics of both classical and contemporary empiricism does not necessarily drive one back to Aristotelian natures" (p. 129).

Interestingly, Cartwright (1999) might not be an avid supporter of capacities. In particular, Cartwright (1999) ponders, instead of capacities, "some related non-Humean notion" (p. 89) may further our understanding of scientific knowledge.

Giere (2008) takes it as a sign that “a robust notion of causality” (p. 129) might save Cartwright from the charges of superrealism, while at the same time it might let her take a non-Humean stance concerning laws of nature. What does “a robust notion of causality” mean? Giere (2008) explains his notion thusly:

As an alternative to Cartwright’s view of principles as describing capacities, I would now like to suggest that we can instead take them to be describing an abstract *causal structure*, or, perhaps better, as abstractly describing a causal structure. By making these models more specific in just the ways described above we can reach general models of causal systems such as Cartwright’s nomological machines, arriving finally at models of specific causal systems. (Giere, 2008, pp. 129-30)

By Ockham’s razor, Giere (2008) adds, causal structures are preferable to capacities:

Indeed, the fact that one can talk about ‘causal powers’ suggests there may not be much real difference between invoking causal structures and invoking capacities. In the end, one may be able to do all the work that needs doing with nothing more than a robust notion of causality and thus avoid introducing capacities in addition to causes. (Giere, 2008, p. 130)

Giere (2008) is also aware that Cartwright (1989, 1999) puts the cart before the horse concerning capacities: “Cartwright argues that capacities are implicit in our scientific practice and thus not objectionably metaphysical” (p. 130). However, scientific practice does not, implicitly or explicitly, concern capacities because Giere (2008) interprets what science ultimately needs differently: “I would argue that the practice [Cartwright] cites only goes so far as [to implicate] casual structures, not capacities” (p. 130). Giere’s (2008) notion of causal structure seems to be a promising alternative to capacities as “some related non-Humean notion” (Cartwright, 1999, p. 89).

Which path should a Humean about laws take? As for future studies, Psillos’s (2014) notion of laws of nature as natural patterns is promising. I will not get into the technicalities of Psillos’s (2014) notion here since it is beyond the scope of this thesis. Psillos (2014) contends that “a law of nature is a regularity that is

characterised by the unity of a *natural* pattern” (p. 24). A pattern is “a repeatable and recurring network of stable similarities and differences among various entities” (Psillos, 2014, p. 22). Moreover, “[n]atural patterns involve natural properties” (Psillos, 2014, p. 24). Put differently, laws are “natural-pattern-involving regularities and yet there is no pattern-enforcer (of distinct metaphysical type)” (Psillos, 2014, p. 25). That is, laws do not require a law-maker because the world “*has a regularity structure*, in which, by virtue of their patterns, regularities stand in certain relations to each other” (Psillos, 2014, p. 25). Psillos then concludes that “[n]atural patterns do not exist in isolation from each other but form a network” (Psillos, 2014, p. 26). Psillos (2014) takes his account as a variant of the MRL view, yet “with the further advantage that the best system is one that captures the network of regularities ... that there is in the world” (p. 25). Psillos (2014, p. 25) expresses that his proposed account is in need of further development, but it is a promising Humean account after all, since it can amend the best systems account against the problems of identification. Indeed, Psillos’s (2014) account makes the least of metaphysics, to which this thesis subscribes.

6.3 Final remarks

After sketching briefly in which direction Humeans and non-Humeans should further current knowledge about laws of nature, I contend that the Humeanism, especially the MRL account and its variant Psillos (2014), is preferable to the non-Humeanism because the former is not only as epistemologically powerful as the latter, but it is also more parsimonious than the latter ontologically. It is likely that future studies concerning Humean accounts of laws, instead of the non-Humean ones, can bring about a more complete understanding of what laws are.

REFERENCES

- Armstrong, D. M. (1978). *Universals and scientific realism* (2 volumes). Cambridge, England: Cambridge University Press.
- Armstrong, D. M. (1983). *What is a law of nature?* Cambridge, England: Cambridge University Press.
- Armstrong, D. M. (1993). The identification problem and the inference problem. *Philosophy and Phenomenological Research*, 53(2), 421-422.
- Armstrong, D. M. (1997a). *A world of states of affairs*. Cambridge, England: Cambridge University Press.
- Armstrong, D. M. (1997b). Singular causation and laws of nature. In: J. Earman & J. Norton (Eds.), *The Cosmos of Science* (pp. 498-511). Pittsburgh, PA: Pittsburgh University Press.
- Armstrong, D. M. (2012). Defending categoricalism. In: A. Bird, B. Ellis & H. Sankey (Eds.), *Properties, powers and structures* (pp. 27-33). New York, NY: Routledge.
- Bigelow, J., Ellis, B., & Lierse, C. (1992). The world as one of a kind: Natural necessity and laws of nature. *The British Journal for the Philosophy of Science*, 43(3), 371-388.
- Bird, A. (1998). Dispositions and antidotes. *The Philosophical Quarterly*, 48(191), 227-234.
- Bird, A. (2001). Necessarily, salt dissolves in water. *Analysis*, 61(272), 267-274.
- Bird, A. (2007). *Nature's metaphysics: Laws and properties*. New York, NY: Oxford University Press.
- Bird, A. (2009). Structural properties revisited. In: T. Handfield (Ed.), *Dispositions and Causes* (pp. 215-241). Oxford, United Kingdom: Clarendon Press.
- Bird, A. (2012). Monistic dispositional essentialism. In: A. Bird, B. Ellis & H. Sankey (Eds.), *Properties, powers and structures* (pp. 35-42). New York, NY: Routledge.
- Bodnar, I. (2018). Aristotle's natural philosophy. *The Stanford encyclopedia of philosophy*. Retrieved April 13, 2018, from <http://plato.stanford.edu>.
- Carroll, J. (1990). The Humean tradition. *The Philosophical Review*, 99(2), 185-219.
- Cartwright, N. (1989). *Nature's capacities and their measurements*. New York, NY: Oxford University Press.

- Cartwright, N. (1995). Précis of Nature's Capacities and their Measurement. *Philosophy and Phenomenological Research*, 55(1), 153-156.
- Cartwright, N. (1997). Where do laws of nature come from? *Dialectica*, 51(1), 65-78.
- Cartwright, N. (1998). Where laws of nature come from? In: M. Paul (Ed.), *Nancy Cartwright: Laws, capacities and science* (pp. 1-30). Münster, Germany: LIT-Verlag.
- Cartwright, N. (1999). *The dappled world: A study of the boundaries of science*. Cambridge, England: Cambridge University Press.
- Cartwright, N. (2007a). *Hunting causes and using them*. Cambridge, England: Cambridge University Press.
- Cartwright, N. (2007b). What makes a capacity a disposition? In: M. Kistler & J. Nicod (Eds.), *Dispositions and causal powers* (pp. 195-206). London, United Kingdom: Ashgate.
- Cartwright, N. (2008). Reply to Stathis Psillos. In: S. Hartmann, C. Hoefer & L. Bovens (Eds.), *Nancy Cartwright's philosophy of science* (pp. 195-197). New York, NY: Routledge.
- Cartwright, N. (2009). Causal laws, policy predictions, and the need for genuine powers. In: T. Handfield (Ed.), *Dispositions and causes* (pp. 127-157). Oxford, United Kingdom: Clarendon Press.
- Cartwright, N., & Ward, K. (Eds.). (2016). *Rethinking order: After the laws of nature*. New York, NY: Bloomsbury Publishing.
- Chakravartty, A. (2003). The dispositional essentialist view of properties and laws. *International Journal of Philosophy of Studies*, 11(4), 393-413.
- Chakravartty, A. (2007). *A Metaphysics for scientific realism: Knowing the unobservable*. Cambridge, England: Cambridge University Press.
- Chakravartty, A. (2009). Making a Metaphysics for Nature. *Metascience*, 18(1), 75-79.
- Chakravartty, A. (2010). Metaphysics between the sciences and philosophies of science. In: P. D. Magnus & J. Busch (Eds.), *New waves in philosophy of science* (pp. 59-77). Hampshire, United Kingdom: Palgrave Macmillan.
- Chakravartty, A. (2013a). Dispositions for scientific realism. In: R. Groff & J. Greco (Eds.), *Powers and capacities in philosophy: The new Aristotelianism* (pp. 113-127). New York, NY: Routledge.

- Chakravartty, A. (2013b). On the prospects of naturalized metaphysics. In: D. Ross, J. Ladyman & H. Kincaid (Eds.), *Scientific metaphysics* (pp. 27-50). New York, NY: Oxford University Press.
- Chakravartty, A. (2017). Saving the scientific phenomena: What powers can and cannot do. In: J. D. Jacobs (Ed.), *Putting powers to work* (pp. 24-37). New York, NY: Oxford University Press.
- Choi, S. (2006). The simple vs. reformed conditional analysis of dispositions. *Synthese*, 148(2), 369-379.
- Choi, S. (2008). Dispositional properties and counterfactual conditionals. *Mind*, 117(468), 795-841.
- Choi, S. & Fara, M. (2012). Dispositions. *The Stanford encyclopedia of philosophy*. Retrieved April 15, 2018, from <http://plato.stanford.edu>.
- Cross, T. (2005). What is a Disposition? *Synthese*, 144(3), 321-341.
- Corry, R. (2011). Can dispositional essences ground the laws of nature? *Australasian Journal of Philosophy*, 89(2), 263-275.
- Dretske, F. I. (1977). Laws of nature. *Philosophy of Science*, 44(2), 248-268.
- Earman, J. (1984). Laws of nature: The empiricist challenge. In: R. Bogdan (Ed.), *D. M. Armstrong* (pp. 191-223). Dordrecht, Netherlands: D. Reidel Publishing Company.
- Ellis, B. (2000). Causal laws and singular causation. *Philosophical and Phenomenological Research*, 61(2), 329-351.
- Ellis, B. (2001). *Scientific essentialism*. Cambridge, England: Cambridge University Press.
- Ellis, B. (2009). *The metaphysics of scientific realism*. New York, NY: Acumen.
- Ellis, B. & Lierse, C. (1994). Dispositional essentialism. *Australasian Journal of Philosophy*, 72(1), 27-45.
- Fara, M. (2005). Dispositions and habituals. *Noûs*, 39(1), 43-82.
- Feynman, R. (1967). *The character of physical law*. Cambridge, MA: The MIT Press.
- Giere, R. N. (2008). Models, metaphysics and methodology. In: S. Hartmann, C. Hoefer & L. Bovens (Eds.), *Nancy Cartwright's philosophy of science* (pp. 123-133). New York, NY: Routledge.
- Goodman, N. (1955). *Fact, fiction and forecast*. Cambridge, MA: Harvard University Press.

- Hacking, I. (1983). *Representing and intervening*. Cambridge, England: Cambridge University Press.
- Hall, N. (2010). David Lewis's metaphysics. *The Stanford encyclopedia of philosophy*. Retrieved April 13, 2018, from <http://plato.stanford.edu>.
- Handfield, T., & Bird, A. (2008). Dispositions, rules, and finks. *Philosophical Studies*, 140(2), 285-298.
- Harré, R. & Madden, E. H. (1975). *Causal powers: Theory of natural necessity*. Oxford, United Kingdom: Blackwell.
- Hawthorne, J., & Manley, D. (2005). Stephen Mumford. Dispositions. *Noûs*, 39(1), 179-195.
- Hoefer, C. (2003). For fundamentalism. *Philosophy of Science*, 70(5), 1401-1412.
- Hu, Q. (2004). The nature of the electron [Abstract]. *Physics Essays*, 17(4), 442-458.
- Hütteman, A. (1998). Laws and dispositions. *Philosophy of Science*, 65(1), 121-135.
- JF Griffiths, A., Gelbart, W. M., Miller, J. H. & Lewontin, R. C. (1999). *Modern genetic analysis: Integrating genes and genomes*. New York, NY: W. H. Freeman.
- Johansson, I. (1998). Pattern as an ontological category. In: G. Nicola (Ed.), *Formal ontology in information systems* (pp. 86-94). Amsterdam, Netherlands: IOS Press.
- Lange, M. (1993). Lawlikeness. *Noûs*, 27(1), 1-21.
- Lewis, D. K. (1972). Psychophysical and theoretical identifications. *Australasian Journal of Philosophy*, 50(3), 249-258.
- Lewis, D. K. (1973). *Counterfactuals*. Cambridge, MA: Harvard University Press.
- Lewis, D. K. (1983). New work for a theory of universals. *Australasian Journal of Philosophy*, 61(4), 343-377.
- Lewis, D. K. (1986). *Philosophical papers: Volume II*. New York, NY: Oxford University Press.
- Lewis, D. K. (1997). Finkish dispositions. *The Philosophical Quarterly*, 47(187), 143-158.
- Lowe, E. J. (1998). *The possibility of metaphysics*. New York, NY: Oxford University Press.
- Mackie, J. L. (1977). Dispositions, grounds, and causes. *Synthese*, 34(4), 361-369.

- Manley, D. & Wasserman, R. (2008). On linking dispositions and conditionals. *Mind*, 117(465), 59-84.
- Martin, C. B. (1994). Dispositions and conditionals. *The Philosophical Quarterly* (1950-), 44(174), 1-8.
- Maudlin, T. (1993). Nature's Capacities and Their Measurement by Nancy Cartwright. *The Journal of Philosophy*, 90(11), 599-603.
- Maudlin, T. (2007). *The metaphysics within physics*. New York, NY: Oxford University Press.
- Maxwell, G. (1970a). Theories, Perception, and Structural Realism. In: R. G. Colodny (Ed.), *The nature and function of scientific theories* (pp. 3-34) Pittsburgh, PA: University of Pittsburgh Press.
- Maxwell, G. (1970b). Structural Realism and the Meaning of Theoretical Terms. In: M. Radner & S. Winokur (Eds.), *Minnesota studies in the philosophy of science*, vol. IV. Minneapolis, MN: University of Minnesota Press.
- Mellor, D. H. (2000). The semantics and ontology of dispositions. *Mind*, 109(436), 757-780.
- Molnar, G. (1999). Are dispositions reducible? *The Philosophical Quarterly*, 49(194), 1-17.
- Molnar, G. (2003). *Powers: A study in metaphysics*. New York, NY: Oxford University Press.
- Morrison, M. (1995). Capacities, tendencies and the problem of singular causes. *Philosophy and Phenomenological Research*, 55(1), 163-168.
- Mumford, S. (1998). *Dispositions*. New York, NY: Oxford University Press.
- Mumford, S. (2004). *Laws in nature*. New York, NY: Routledge.
- Mumford, S. & Anjum, R. L. (2011). *Getting causes from powers*. New York, NY: Oxford University Press.
- Mumford, S. & Tugby, M. (2013). What is the metaphysics of science? In: S. Mumford & M. Tugby (Eds.), *Science and metaphysics* (pp. 3-26). New York, NY: Oxford University Press.
- Price, H. (1991). Nature's capacities and their measurement. Nancy Cartwright. *Isis*, 82(3), 605-606.
- Propulsion. (n.d.). Retrieved from <http://www.qrg.northwestern.edu/projects/vss/docs/propulsion/1-what-is-an-atom.html>.

- Psillos, S. (2002). *Causation and explanation*. Stocksfield, United Kingdom: Acumen.
- Psillos, S. (2006). What do powers do when they are not manifested? *Philosophy and Phenomenological Research*, 72(1), 137-156.
- Psillos, S. (2008). Cartwright's realist toil: From entities to capacities. In: S. Hartmann, C. Hoefer & L. Bovens (Eds.), *Nancy Cartwright's philosophy of science* (pp. 167-194). New York, NY: Routledge.
- Psillos, S. (2014). Regularities, natural patterns and laws of nature. *Theoria. Revista de Teoría, Historia y Fundamentos de la Ciencia*, 29(1), 9-27.
- Ramsey, F. P. (1928). Universals of law and of fact. In: D. H. Mellor (Ed.), *F. P. Ramsey, foundations: Essays in philosophy, logic, mathematics and economics* (pp. 128-132). London, United Kingdom: RKP.
- Ramsey, F. P. (1978). *Foundations*. London, United Kingdom: Routledge and Kegan Paul.
- Reichenbach, H. (1947). *Elements of symbolic logic*. New York, NY: Macmillan.
- Robus, O. M. (2015). *Does science license metaphysics?* [PDF file]. Retrieved from http://philsci-archive.pitt.edu/11149/1/OMR_Does_Science_License_Metaphysics.pdf.
- Rosenberg, A. (1984). Mackie and Shoemaker on dispositions and properties. *Midwest Studies in Philosophy*, 9(1), 77-91.
- Rosenberg, J. F. (2007). *Wilfrid Sellars: Fusing the images*. New York, NY: Oxford University Press.
- Rudder Baker, L. (2007). *The metaphysics of everyday life: An essay in practical realism*. Cambridge, England: Cambridge University Press.
- Schlosser, M. E. (2017). Lewis' conditional analysis of dispositions revisited and revised. *Acta Analytica*, 1-13.
- Sellars, W. (1963). *Science, perception and reality*. Atascadero, CA: Ridgeview P. C.
- Shoemaker, S. (1980). Causality and properties. In: P. van Inwagen (Ed.), *Time and cause* (pp. 109-135). New York, NY: Springer.
- Shoemaker, S. (1984). *Identity, cause and mind: Philosophical essays*. Cambridge, England: Cambridge University Press.
- Soto, C. (2015). The Current State of the Metaphysics of Science Debate. *Philosophica*, 90(1), 23-60.

- Steinberg, J. R. (2010). Dispositions and subjunctives. *Philosophical Studies*, 148(3), 323-341.
- Swinburne, R. G. (1980). Properties, causation and projectibility: Reply to Shoemaker. In: L. J. Cohen & M. Hesse (Eds.), *Applications of inductive logic* (pp. 313-320). Oxford, United Kingdom: Clarendon Press.
- Swoyer, C. (1982). The nature of natural laws. *Australasian Journal of Philosophy*, 60(3), 203-223.
- The Faculty of Applied Sciences of TU Delft. (n.d.). The Variable energy positron beam (VEP). Retrieved from <https://www.tudelft.nl/en/faculty-of-applied-sciences/about-faculty/departments/radiation-science-technology/neutron-positron-methods-for-materials/research-facilities/positron-facilities/the-variable-energy-positron-beam/>.
- Tooley, M. (1977). The nature of laws. *Canadian Journal of Philosophy*, 7(4), 667-698.
- Van Fraassen, B. (1989). *Laws and symmetry*. Oxford, United Kingdom: Clarendon Press.
- Van Fraassen, B. (1993). Armstrong, Cartwright, and Earman on laws and symmetry. *Philosophy and Phenomenological Research*, 53(2), 431-444.
- Vetter, B. (2012). Dispositional essentialism and the laws of nature. In: A. Bird, B. Ellis & H. Sankey (Eds.), *Properties, powers and structures: Issues in the metaphysics of realism* (pp. 201-215). New York, NY: Routledge.
- Vetter, B. (2013). Multi-track dispositions. *The Philosophical Quarterly*, 63(251), 330-352.
- Vetter, B. (2014). Dispositions without conditionals. *Mind*, 123(489), 129-156.
- Wartofsky, W. M. (1967). Metaphysics as heuristic for science. In: R. S. Cohen & M. W. Wartofsky (Eds.), *Proceedings of the Boston Colloquium for the philosophy of science 1964/1966. Boston Studies in the Philosophy of Science*, 3 (pp. 123-172). Dordrecht, Netherlands: Springer.
- Williams, N. E. (2011). Dispositions and the argument from science. *Australasian Journal of Philosophy*, 89(1), 71-90.
- Yli-Vakkuri, J. (2010). Conditional and habitual analyses of disposition ascriptions. *The Philosophical Quarterly*, 60(240), 624-630.