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The Ontology Of Complex Systems:

Wimsatt On Emergence

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Abstract

This dissertation aims to offer a perspective on Wimsatt's work, emphasizing its originality in addressing ontological issues related to emergence. The first section provides a concise overview of Wilson's concept of Weak Emergence, serving as common ground for theorists aligned with nonreductive physicalism. Turning to the realm of complex systems, we explore Wilson's treatment of them through her Degrees of Freedom (DOF) framework.

In the second section, the focus shifts to an analysis of Wimsatt's conceptual apparatus, commencing with the exploration of robustness and its ontological and epistemological implications. Through this examination, Wimsatt's departure from classical theories of emergentist ontology becomes apparent, showcasing a multifaceted approach rooted in a pragmatic necessity.

The third section delves into Wimsatt's ontological perspective on complex systems, which is then translated and contextualized within the framework provided by Wilson. Throughout this section, comparisons are drawn where possible, highlighting instances where Wimsatt's conceptual originality diverges from schematic accounts, such as those presented by Wilson.

In conclusion, this dissertation offers a comprehensive analysis of Wimsatt's contributions to the understanding of emergence, illuminating both the alignment with and departure from prevailing theories. The exploration seeks to enhance our appreciation of Wimsatt's nuanced approach and its implications within the broader discourse on emergent phenomena.

Sommario in italiano

Il mio obiettivo, attraverso questa tesi, è stato quello di introdurre il lettore a due approcci normalmente considerati separati alle teorie emergentiste. Il primo approccio, trattato estensivamente nel primo capitolo, è quello metafisico di Jessica Wilson. Nel secondo capitolo, invece, ho concentrato la mia attenzione sulle teorie di William Wimsatt, un filosofo della scienza e biologo evoluzionistico americano che nel corso degli anni ha cercato di introdurre una forte componente pragmatica nel discorso sul tema. All'interno della *Conclusione* ho cercato di mettere in luce i punti di affinità e divergenza tra le teorie, mostrando come spesso possano, pur tramite metodologie profondamente diverse, giungere alla stessa conclusione. La mia tesi vorrebbe essere un primo tentativo di unificazione tra queste branche dell'emergentismo filosofico, e fornire delle basi ben delineate per un possibile progetto di ricerca intercategoriale.

All'interno dell'introduzione e del primo capitolo vengono esposti i concetti alla base delle teorie emergentiste metafisiche. Innanzitutto, va notato che ogni teoria emergentista presuppone due concetti interrelati. La *Cotemporal Material Dependence* (Dipendenza Materiale Cotemporale) assicura che tutti i fenomeni emergenti siano in relazione di dipendenza fisica con la loro base sottostante, il che colloca l'emergentismo in contrasto con ogni forma di dualismo. Le condizioni di *Ontological and Causal Autonomy* (Autonomia Ontologica e Causale) sono invece fondamentali per asserire che, nonostante la dipendenza materiale, le entità emergenti possiedono indipendenza e devono essere considerate come diverse dalla propria base in luce dell'universalità delle proprietà esibite. Questo conferisce loro una potenza causale distinta, e di conseguenza anche autonomia sotto il punto di vista ontologico. Va notato poi come questi presupposti vengano giustificati anche tramite il ricorso alle scienze speciali, in particolare in riferimento alla tassonomia e alle leggi teoriche.

In seguito vengono distinte le due correnti della *Weak and Strong Emergence* (Emergenza Debole e Forte). Le teorie deboli, tramite la *Proper Subset Of Powers Condition* (Condizione del Sottoinsieme Proprio di Poteri) giustificano l'autonomia dei fenomeni asserendo che essi possiedono un sottoinsieme dei poteri esercitabili dalla base, che grazie alla differente configurazione portano allo sviluppo di poteri causali distinti. Questo rende l'Emergenza Debole una teoria fisicalista, che ammette la possibilità di prevedere questi fenomeni e di applicare metodi riduzionistici, a condizione che non abbiano intenzioni eliminativiste. I fenomeni emergenti devono sempre mantenere l'autonomia loro propria. Le teorie forti, invece, postulano la *New Power Condition* (Condizione del Potere Nuovo). Essa implica che i poteri di alcuni fenomeni emergenti siano radicalmente nuovi, e di conseguenza non posseduti né riducibili alla base materiale. Questa corrente si pone di conseguenza in diretto contrasto col riduzionismo. Proseguendo, queste condizioni vengono applicate al problema dell'*Overdetermination* (Sovradeterminazione) posto da Jaegwon Kim, e viene mostrato come entrambe ammettono la possibilità per i fenomeni emergenti di avere influenza causale sulla loro base sottostante.

Dopo avere esaminato alcune critiche alla teoria della Weak Emergence, preferita per la sua maggiore compatibilità con vari aspetti pragmatici, viene introdotto il concetto di Degrees Of Freedom (Gradi di Libertà) o DOF in breve. La condizione che li applica porta ad una riformulazione della condizione per l'emergenza debole illustrata sopra, spostando l'attenzione verso il fatto che nel momento in cui andiamo a considerare fenomeni presenti ai livelli superiori di realtà possiamo ignorare diversi dettagli presenti alla base, tra cui lo spin quantistico. Questo è sufficiente per asserire che le entità emergenti, essendo soggette a leggi diverse dalla loro base, dimostrano autonomia ontologica e causale.

Passando alla sezione dedicata a William Wimsatt, viene innanzitutto presentato il concetto di *Robustness* (Robustezza), che funge da base ontologica, epistemologica e metodologica nelle analisi del filosofo. Esso prescrive che un fenomeno, per essere considerato reale, deve ricevere conferme delle proprie proprietà tramite quanti più metodi di analisi indipendenti possibili. Questo concetto trasforma i criteri metodologici utilizzati all'interno dell'analisi scientifica in una base per costruire inferenze metafisiche. Questa attenzione alla metodologia viene ulteriormente rinforzata tramite la valorizzazione di metodi di ricerca euristici, che permettono di costruire schematizzazioni utili a facilitare questo processo di conferma.

All'interno del corpus wimsattiano troviamo poi una rivalutazione sostanziale delle pratiche riduzionstiche. Attraverso la critica a posizioni eliminativiste, che interpretano ontologicamente le proprietà emergenti come nulla di più rispetto alla loro base materiale, vengono sviluppate varie euristiche riduzionistiche. Esse mettono in luce come il riduzionismo sia sensato solamente nel momento in cui richiede capacità computazionali ragionevoli, andando a scardinare quel pregiudizio spesso presentato tramite l'argomentazione del demone di Laplace. La considerazione dell'essere umano come un agente limitato e fallibile porta Wimsatt a porre l'enfasi su quelle istanze in cui l'applicazione del riduzionismo può effettivamente aiutare nella costruzione di spiegazioni ai fenomeni scientifici che ancora la necessitano. Allo stesso tempo viene identificato però un bias costitutivo dei nostri schemi concettuali basato sulla direzione della spiegazione: nonostante siamo solitamente portati a ricercare spiegazioni scendendo di livello, Wimsatt mette in luce come ci siano dei casi (ad esempio la formulazione del concetto di fitness in ambito biologico) che hanno giovato della ricerca di spiegazioni top-down. Queste sono alcune delle considerazione che permettono a Wimsatt di asserire che si può essere allo stesso tempo olisti, o emergentisti, e riduzionisti.

Il fenomeno dell'emergenza viene analizzato tramite due vie diverse. La prima è basata sulla definizione dello statuto ontologico dei *Levels Of Organization* (Livelli di Organizzazione), all'interno dei quali sono locate le entità emergenti. La seconda invece si basa sulla definizione delle proprietà emergenti come non aggregative. Questa seconda via gli ha permesso di asserire l'autonomia di queste proprietà, nonostante possano essere efficacemente analizzate, e in principio anche spiegate interamente, tramite procedure riduzionistiche. La combinazione di queste due vie, che mantengono come base il concetto di robustness e la costruzione di euristiche, lo ha portato alla formulazione del concetto di *Dynamical Autonomy* (Autonomia Dinamica).

Come dimostrato nella *Conclusione*, esso è perfettamente equiparabile ai DOF sviluppati da Wilson, il che ci permette di asserire la validità di entrambe le metodologie di ricerca, e la possibilità di una loro futura associazione.

I temi affrontati sono quindi variegati e spesso complessi, ma spero che nel corso della lettura possa risultare chiaro che esiste una necessità di applicare questa molteplicità di metodologie. Sostenere le tesi in campo emergentista tramite metodologie diversificate, se il concetto di robustness è corretto, andrà sempre a rafforzare la loro validità.

1

Introduction

Emergence, an intellectually stimulating concept at the nexus of philosophy and science, explores the intricate dynamics of complex systems where macro phenomena unfold from the interactions among simpler constituents. This concept reveals that properties or behaviors observable at a larger scale are not readily predictable or evident from examining the system's individual elements at a microscopic level. From the flocking patterns of ducks in V formations and the life-sustaining properties of water to the enigma of consciousness and the intricate designs produced by cellular automata, emergence is observed across various phenomena. These instances all rest on a physical foundation, yet they exhibit ontological and causal autonomy, transcending simple deduction from their underlying bases.

By maintaining the essence of emergence's captivating allure, we underscore its challenge to reductionist perspectives that aim to explain phenomena solely through their constituent parts. Emergence posits a world where the whole transcends its parts, revealing properties that are not mere aggregates but result from complex interactions and dependencies. This paradigm shift invites a deeper exploration into the realm of complexity, urging a reevaluation of our understanding across natural and social sciences.

In essence, emergence showcases the beauty and complexity of systems where the macroscopic level reveals unexpected properties and behaviors, challenging our traditional approaches to understanding the fabric of reality. This concept not only enriches our scientific and philosophical discourse but also illuminates the interconnectedness and unpredictability inherent in the natural world and human society.

1.1 The Fundamental Concepts of Emergence

The first publication on which we will draw our focus is “Metaphysical Emergence”, written by Jessica M. Wilson. In it the author conducts a thorough analysis of many different theoretic approaches to the subject of emergence, which are divided into the two macro schools of thought of Weak and

Strong Emergence. This preliminary distinction is not the only one that comes into play: multiple accounts have been proposed throughout its history, all of which try to make sense of different scientific phenomena from a metaphysical point of view. Throughout her analysis Wilson provides a bridge between abstract philosophical discourse and tangible phenomena, capturing the essence of emergence in a framework that resonates with both theoretical rigor and empirical relevance.

We shall now begin understanding what emergence is about, starting from the first schematic definition provided by the author: "It is the coupling of C*otemporal Material Dependence* with O*ntological and Causal Autonomy* which is most basically definitive of the notion of emergence"[1]. To unpack this dense terminology and its implications, we must first dissect the key components of this statement.

Cotemporal Material Dependence: The concept of cotemporal material dependence refers to the idea that emergent properties or phenomena are materially dependent on their constituent parts at the same point in time. This implies that while emergent properties exist, they do so only as a result of the underlying components' existence and interactions in that specific temporal context. It's a way of acknowledging that while emergent phenomena are distinct, they are not completely detached from their foundational elements.

Ontological Autonomy: Ontological autonomy is a term used to describe the distinct and independent existence of emergent phenomena. In the context of emergence, it means that these phenomena, although rooted in and arising from simpler entities, possess their unique set of properties or behaviours that are not reducible to those of their constituent parts. This autonomy challenges the reductionist view and asserts the existence of higher-level properties that command their own ontological status.

Causal Autonomy: Causal autonomy complements ontological autonomy. It refers to the capacity of emergent phenomena to exert influences and bring about effects that are not merely the sum of the influences and effects of their underlying components. In other words, emergent properties can have causal powers that are distinct from, and in some accounts cannot be wholly explained by, the causal powers of their constituent parts.

The reason for asserting cotemporal material dependence is drawn in its entirety by the sciences, where it is almost universally accepted that the entities which populate our world are ultimately physical. It's important to note that this view puts metaphysical emergence in contrast with any form of dualism.

1 Wilson (2021), p. 1

Ontological and causal autonomy are also justified in light of the special sciences. By taking the point of view of scientific taxonomy and special-science features and laws it is immediately evident that different entities are at minimum pragmatically taken as being organized in different levels of reality, in which they present a distinctive causal efficacy and which are governed by different laws. Take, for example, the human condition: our interactions predominantly occur within our own level of reality, engaging with entities such as food, artifacts, or fellow humans. Our attributes, which include complex mental phenomena like the depth of subjective experiences and ethical reasoning, cannot be simply reduced to the elemental physical components from which we are constructed. Despite being governed by the principles of mechanics, the intricacies of our quantum-spin hold little bearing on our day-to-day existence.

1.2 Weak vs. Strong Emergence

We have seen that theories around emergence are divided into two main groups. We must understand the main theoretical discrepancies between them in order to express a preference and focus our analysis, keeping in mind that our goal is to find an account of emergence which can be both compatible with and useful for scientific research. Following Wilson's analysis and the distinctions provided in her article "Metaphysical Emergence: Weak and Strong" we can examine the most relevant differences between the two approaches starting with the schematic accounts.

> *Strong Emergence*: What it is for token feature *S* to be Strongly metaphysically emergent from token feature *P* on a given occasion is for it to be the case, on that occasion, (i) that *S* cotemporally materially depends on *P*, and (ii) that *S* has at least one token power not identical with any token power of *P*.[2]

We have already analyzed the concept of cotemporal material dependence, which requires emergent feature S to materially depend on the base feature P. What the second part of the definition implies is the concept of *New Power Condition*, which is the defining characteristic of Strong Emergence. This condition requires that the emergent feature S possesses at least one token power that is not identical to any token power of P. This means that S exhibits a capability or effect that is fundamentally new and cannot be traced back to the powers inherent in P.

2 Wilson (2021), p. 53

Before looking at the theoretical implications of this condition we can look at the schematic account of Weak Emergence.

> *Weak Emergence*: What it is for token feature *S* to be Weakly metaphysically emergent from token feature *P* on a given occasion is for it to be the case, on that occasion, (i) that *S* cotemporally materially depends on *P*, and (ii) that *S* has a non-empty proper subset of the token powers had by *P*.[3]

Again, cotemporal material dependence is present in both accounts, as it represents a baseline assumption in any scientific domain. What differs is the second condition, which in this instance entails the concept of *Proper Subset of Token Powers*, which posits that while S arises from P and is dependent on it, the powers or capacities that S exhibits are already contained within the range of powers that P possesses.

What is different, and radically so, is the nature and scope of the emergent properties' powers in relation to their base features. Weak Emergence suggests a form of emergence where the novel properties or behaviours can ultimately be reconciled with the capacities of the base features, maintaining a continuity with physicalist principles. In contrast, Strong Emergence posits a more radical form of novelty, where emergent properties introduce entirely new powers or capacities that transcend the scope of their underlying features. As philosopher David Chalmers states, "We can say that a high-level phenomenon is strongly emergent with respect to a low-level domain when the high-level phenomenon arises from the low-level domain, but truths concerning that phenomenon are not deducible even in principle from truths in the low-level domain"[4]. This aspect of Strong Emergence challenges traditional physicalist ontology by suggesting that higher levels of complexity can give rise to genuinely new causal powers. Wilson's schematic accounts provide a clear conceptual tool for distinguishing between these two forms of emergence, emphasizing the importance of token powers in understanding emergent phenomena.

Let us now turn our head towards the theoretical implications of these two positions, and their compatibility with a more scientifically-aligned stance. The main contrasts between the two theories are those between predictability vs. unpredictability and reductionism vs. irreducibility. Strong Emergence considers some emergent properties as fundamentally new, entailing an impossibility of both prediction and reduction. Through the introduction of novel causal powers and laws of nature,

3 Wilson (2021), p. 75

4 Chalmers (2006), p. 1

which would not be present at lower levels of organization, it poses a relevant challenge to physicalist ontology and current scientific paradigms.

On the other hand Weak Emergence through the *Proper Subset of Token Powers* condition, allows for in principle predictability and reducibilty as stated by Mark Bedau in his paper Weak Emergence: “So, if we are given a system’s microdynamic and all relevant external conditions, then in principle we can derive the system’s behavior because we can simulate the system and observe its behavior for as long as necessary. And if we can derive how the system will behave, we can predict its future behavior with complete certainty.”[5]. Other authors argue for an in principle explainability of emergent phenomena, rather than a predictability, which is a less commiting stance which we will be coming up later. This viewpoint aligns with a scientific perspective that seeks to unravel complex phenomena through an understanding of their simpler, constituent elements. Weak Emergence is fully grounded in a physicalist ontology yet diverges from strict reductionism, especially of the eliminative kind. It suggests a richer, complex reality, in stark contrast to, for example, Quine’s metaphorical 'desert' of minimal entities. Reflecting on this, Quine asserts, "A theory is committed to those and only those entities to which the bound variables of the theory must be supposed to refer in order that the affirmations made in the theory be true."[6] This underscores the evolution of the positions taken in philosophy of science, going from the sparse ontological commitments Quine advocates for to the rich complexity acknowledged by theories of Weak Emergence. Another aspect in which the two positions typically differ is the structure they assign to causal relationships: while Weak Emergence typically argues for a causal structure which must only include interactions from lower to higher levels, Strong Emergence allows more easily for a bi-directional causal influence. Both “In principle” talk and bi-directional causality are problematic notions which will be thoroughly analyzed later through Wimsatt’s works.

Given the pragmatic focus of this thesis, we will be primarily concentrating on Weak Emergence, which is more closely aligned with a pragmatic approach, given that we value practicality and utility in understanding and engaging with the world, thanks to its grounding in physicalism. Drawing again from Bedau, we can more easily find practical applications in Weak Emergence, as exemplified by his analysis of cellular automata, which provide a clear illustration in how it manifests in complex systems. For these reasons he concludes his paper with the following statement: “As Conway’s Game of Life and Packard’s model of evolving sensorimotor agents illustrate, weak emergence is ubiquitous in the burgeoning, interdisciplinary nexus of scientific research about complex

5 Bedau (1997), p. 19

6 Quine (1948), p. 33

systems. The central place of weak emergence in this thriving scientific activity is what provides the most substantial evidence that weak emergence is philosophically and scientifically important. It is striking that weak emergence is so prominent in scientific accounts of exactly those especially puzzling phenomena in the natural world— such as those involving life and mind—that perennially generate sympathy for emergence. Can this be an accident?"[7].

While Weak Emergence acknowledges the novelty and unpredictability of emergent phenomena, it does so within a framework that values explainability and practical utility. This alignment makes it particularly suitable for a pragmatic approach to understanding and exploring complex systems. This does not imply an absolute refusal of the more nuanced positions present in Strong Emergence. Throughout our analysis it will become clear that, when applied to specific contexts, both of these conceptual schemes can find useful and insightful applications.

7 Bedau (1997), p. 22

2

Weak Emergence

Given the reasons for focusing on Weak Emergence in our journey through the multi-faceted approaches to the subject, we must now provide some additional key operative notions to accompany the ones introduced earlier: Cotemporal Material Dependence—the concept that higher-level entities are entirely physical, being fully constituted by their foundational, lower-level entities; alongside the concepts of ontological and causal autonomy, highlighting the distinct existence and influence that emergent phenomena wield, independent from their base constituents.
First, let's provide a brief explanation of what is meant by types and tokens in our context:

1. *Types*: The concept of a "type" refers to a general category or class of things that share certain characteristics. Types are abstract entities that denote the general form or idea of something. For instance, the word "chair" as a type refers to the general concept or category of all chairs, encompassing any physical manifestation of a chair.

2. *Tokens*: A "token," on the other hand, refers to a specific instance or occurrence of a type. Tokens are concrete, individual manifestations of a type within the physical world. For example, the chair in your living room is a token of the type "chair." Each individual chair, with its unique features and location, is a distinct token of the broader type.

These notions will be recurring throughout our analysis. It's important to note that most theories refer to tokens because they permit to analyze specific instances of relevant phenomena, drawn from the special sciences, which allow support of the arguments proposed. An instance in which it is more useful discussing types would be an inter-level analysis of special science laws and theories. Also, keep in mind that, when talking about features, Wilson implies a reference to spatiotemporally located tokens of a given type.

2.1 Overdetermination: Problems and Solutions

We can now continue on our journey by presenting Jaegwon Kim's overdetermination argument, alongside possible solutions. Behind the argument stands the goal of invalidating theories which propose the possibility of higher-level causation in some contexts. Following Wilson[8], we will present the argument by first introducing the premises which lead to it:

1. *Dependence*: We have already highlighted how dependence is a fundamental notion in the discussion of emergence. The dependence at issue in Kim's argument asserts that the occurrence of a special-science feature minimally nomologically supervenes on a base feature. What this means is that in worlds governed by laws similar to our own (hence nomologically instead of metaphysically, which would entail any possible worlds) any token of the supervenient or higher-level feature must be related to a token of the base (fundamental level) type. This entails that if a token of the base type occurs, then the supervenient type token must also occur.
2. *Reality*: This premise grants reality both to higher and lower-level features.
3. *Efficacy*: Higher-level features possess causal efficacy.
4. *Distinctness*: Higher-level features are distinct from their basis.

These first four premises are considered neutral in an emergentist context, given that they are assumed by most if not all theories. The following ones will require a deeper analysis.

5. *Physical Causal Closure*: This premise was implicit in our discussion around the differences between Weak and Strong Emergence. Standardly assumed in physicalist positions, this premise asserts that any higher-level feature must possess a sufficient lower-level physical cause. This view extends the concept of cotemporal material dependence to causality.

We can now introduce the last premise, which will constitute the core of Kim's arguments:

6. *Non-overdetermination*: Excluding cases of the double-rockthrow variety, which are literally instances where the same sufficient cause happens twice, like throwing two rocks simultane-

8 Wilson (2021), p. 40

ously against a window in order to break it, no causal overdetermination is admitted for any effect by two distinct and individually sufficient cotemporal causes.

Two separate cases are presented by Wilson in which overdetermination would be happening, alongside useful diagrams which facilitate their understanding. I am citing them in their entirety[9]:

First (case 1), suppose that *S* causes special-science feature *S** on a given occasion (compatible with *Efficacy*). *S** is cotemporally materially dependent on some base feature *P** (*Dependence*), such that *P** necessitates *S**, with at least nomological necessity. Moreover, *P** has a sufficient purely lower-level physical cause (*Physical Causal Closure*)—plausibly, and without loss of generality, *P*. If *P* causes *P**, and *P** (at least nomologically) necessitates *S**, then it is plausible that *P* causes *S**, by causing *P**. So, it appears, both *P* and *S* cause *S**, and given that *P* and *S* are both real and distinct (*Reality*, *Distinctness*), *S** is causally overdetermined; moreover (given *Dependence*), this overdetermination is not of the double-rockthrow variety (contra *Non-overdetermination*). Diagrammatically, the case is as in Figure 2.1, with bold lines representing causation:

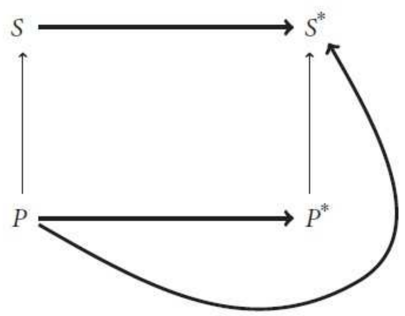

Figure 2.1 Case 1 of the problem of higher-level causation: *S* causes *S**

Second (case 2), suppose that *S* causes some base feature *P** on a given occasion (compatible with *Efficacy*). *P** has a sufficient purely lower-level physical cause (*Physical Causal Closure*)—plausibly, and without loss of generality, *P*. So, it appears, both *P* and *S* cause *P**, and given that *P* and *S* are both real and distinct (by *Reality* and *Distinctness*), *P** is causally overdetermined; moreover,

9 Wilson (2021), pp. 42-43

(given *Dependence*) this overdetermination is not of the double-rock-throw variety (contra *Non-overdetermination*). Diagrammatically, the case is as in Figure 2.2:

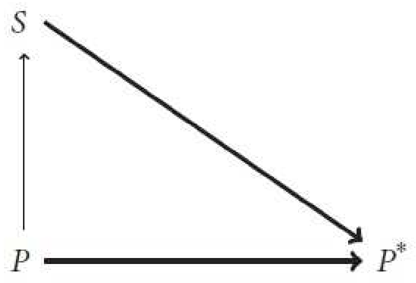

Figure 2.2 Case 2 of the problem of higher-level causation: *S* causes P^*

While Kim's goal with this argument is to defend a reductionist position, by asserting that it entails the rejection of the distinction between special-science feature and their base features, many different strategies have been elaborated in response to it, all of which reject one of the premises.

By denying *Dependence* authors have defended dualistic positions, which would consider higher level features as a different kind of substance; this is especially relevant when talking about the idea that there might be some kind of mental "stuff" in our universe, which is both irreducible to and autonomous from the physical. Eliminativist positions would deny the *Reality* of higher-level phenomena, adopting the kind of reductionistic positions we touched upon earlier. Rejection of *Efficacy* constitutes the basis for an Epiphenomenalist position, and rejection of *Distinctness* would indicate an alignment with reductive physicalist positions.

All of these objections to overdetermination, while available, do not fit into the scheme for metaphysical emergence. This is why we have to shift our focus towards the denial of either *Physical Causal Closure* or *Non-overdetermination*, which respectively align with Strong and Weak versions of emergentism.

2.1.1 Strong Emergence and Downward Causation

Before delving into the intricacies of Weak Emergentist positions, we can briefly illustrate how the denial of *Physical Causal Closure* gives rise to the *New Power Condition*. Denying it entails the fact that some lower-level physical effects can have a cause which is not purely lower-level. In other words, we open the possibility for top-down causal relationships, standing in contrast with physicalist views.

Van Gulick's characterization of "radical emergence" is an accessible example of what a typical Strong position would look like: "If [...] system-level powers were not determined by the laws governing the powers of their parts, then that would seem to imply the existence of powers that could override or violate the laws governing the powers of the parts [...] It is in this respect that radically emergent powers would pose such a direct challenge to physicalism, since they would threaten the view of the physical world as a closed causal system."[10]. The *New Power Condition* provides a schematic illustration of the idea that some features, while being cotemporally materially dependant on their base, possess powers which their base features do not confer directly.

> *New Power Condition*: Token feature S has, on a given occasion, at least one token power not identical with any token power of the token feature P upon which S cotemporally materially depends, on that occasion.

As already noted above, the Strong emergentist argues for the fundamental novelty of some higher-level features, meaning that this novelty shouldn't be understood in a compositional way. Among the powers a high-level features would have, are those that render it capable of exerting causal influences upon their base constituents. Let' see how the Strong emergentist approaches downward causation through the implementation of *Physical Causal Closure*: again, given the high technicality of the arguments, I will be citing Wilson's analysis directly[11], only in relation to case 2 of Kim's initial argumentation:

"In the case where special-science feature *S* causes a base feature *P** (case 2), the Strong emergentist strategy involves, to start, the supposition that *S* satisfies the *New Power Condition* specifically in having a fundamentally novel power to bring about *P**. For example, *S* might be a Strongly

10 Van Gulick (2001), pp. 18-19, in Wilson (2021), p. 50

11 Wilson (2021), p. 52.

emergent state of being thirsty, which depends on base feature *P*, and which in the circumstances causes a physical reaching for a nearby glass of water *P**. On this assumption, *P** does not, contrary to the assumption of *Physical Causal Closure*, have a sufficient purely lower-level physical cause: as per the *New Power Condition*, *P* has no token power identical with *S*'s token power to cause *P**; hence either *P* is not at all a cause of *P** (does not have any power to cause *P**), or else, if *P* can be understood to cause *P** (that is, to have a power to cause *P**), *P* has this power only in a derivative way, in virtue of *P*'s being a dependence base for *S*, which non-derivatively has the power at issue. Either way, *P* fails to be a sufficient purely lower-level physical cause of *P**; and without loss of generality, it moreover follows that *P** has no sufficient purely lower-level physical cause, contra *Physical Causal Closure*, and overdetermination is avoided, as in figure 2.3:

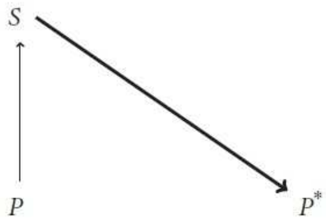

Figure 2.3 The Strong emergentist's response to case 2

Before moving on to the treatment Weak Emergence offers to the topic of downward causation, let's consider another specific instance in which it might be the most adequate explanation of a phenomenon. In the context of predator-prey relationships, consider the predator's presence (S) as the emergent phenomenon influencing genetic changes in the prey (P*), evolving from the baseline genetic material (P) through coevolution. This dynamic illustrates how emergent states (S) have novel powers to cause significant evolutionary adaptations (P*) in prey, which are not merely the result of lower-level genetic conditions (P), thus challenging the principle of Physical Causal Closure by demonstrating an emergent influence on physical traits without direct lower-level causes.[12]

2.1.2 Weak Emergence and Downward Causation

Given that Wilson uses in this section Non-reductive Physicalism as a synonym for Weak Emergence, it is time to give a proper definition of this terminology.

12 Yoshida, Jones, Ellner, (2003). I recommend reading this brief paper for an illustration of a real-world case of downwards causation. The conclusion of the paper states "Our study indicates that ecologists must consider ongoing rapid evolution when exploring the mechanisms underlying the dynamics of populations and food webs. Evolutionary and ecological dynamics must be understood in concert.".

It still maintains the principles of physicalism, which just entails that everything is ultimately grounded in the physical phenomena, which is the same principle elucidated by *Cotemporal Material Dependence*. But it also considers the fact that complex phenomena are not fully explainable by reduction to their base-level, highlighting both the significance and causal powers of higher-level phenomena, without neglecting their grounding on physical base features. As you can tell from this description, it is identical in its principles to that of Weak Emergence.

We saw how the solution proposed by Strong Emergentists to the problem of overdetermination presupposed the rejection of *Physical Causal Closure*. Unlike them, Non-reductive Physicalists take issue with another premise, *Non-overdetermination*. What they argue for, is the possibility for both special-science and base features of sufficiently causing an effect. We will soon explore the reasons why they think the relation between the causes can be interpreted coherently without accepting the conditions imposed by Kim.

First we must introduce the *Proper Subset of Powers Condition*, which serves a basis for Weak Emergence. Following Wilson's presentation, we will compare it with the *Token Identity of Powers Condition*, which could be seen as its precursor because of its applicability to both reductive and non-reductive physicalist positions.

> *Token Identity of Powers Condition*: Every token power of token feature *S*, on a given occasion, is identical with a token power of the token feature *P* on which *S* cotemporally materially depends, on that occasion.

We can immediately note how this condition maintains the validity of *Physical Causal Closure*, by grounding the relation between higher and lower-level features on the identity of token powers. But assuming an undiscriminated relation does not allow to explain how the problematic cases we saw above could be avoided. This is why non-reductive physicalists usually accept a stronger condition.

> *Proper Subset of Powers Condition*: Token feature *S* has, on a given occasion, a non-empty proper subset of the token powers of the token feature *P* on which *S* cotemporally materially depends, on that occasion.

This condition finally allows us to tackle the problem of higher-level causation from a Weak emergentist point of view. First, we must note that talking about a "non-empty proper subset of the token powers" implies an ontological distinction between features *S* and *P*, as confirmed by contrast with Leibniz's Law. The law, which is also known as the Principle of the Identity of Indiscernibles states that: "if, for every property *F*, object *x* has *F* if and only if object *y* has *F*, then *x* is identical to *y*. Or in the notation of symbolic logic: $\forall F(Fx \leftrightarrow Fy) \rightarrow x{=}y$."[13]. The distinction can also be transposed to the causal domain, because being a proper subset, thus different from the base set of powers, allows for distinctive causal efficacy without necessitating wholly new powers, as is the case for Strong Emergence. It becomes particularly evident through the analysis of cases of multiple realizability. Drawing upon the earlier example of thirst provided by Wilson[14], if we assume that S possesses a proper subset of powers which also P has, enabling the action of reaching for a glass of water E, it wouldn't make any difference to the occurrence of E if S were realized by P′, which also allows for S having that same subset of powers. As Wilson notes, S shows some degree of causal autonomy: "That *S*'s distinctive power profile contains just those powers relevant or 'proportional' to *E*'s production provides a principled reason for taking *S*'s efficacy vis-à-vis *E* to be distinctively different from *P*'s, notwithstanding that (as per *S*'s satisfaction of the *Token Identity and Proper Subset* conditions on token powers), *S* doesn't cause anything that *P* (or other realizers of *S*'s type, on other occasions) doesn't (or don't) also cause."[15] Multiple realizability is described by Antony as a red herring, because it is sometimes misinterpreted as the assertion that a higher-level feature could be embodied in something other than their physical realizer, which is especially relevant in the discussions around mental properties. What is actually argued for is that, in this case psychological kinds must be treated with the right degree of ontological and causal autonomy, in order to allow for accurate functional descriptions and generalizations, which are as or more useful to the understanding of our mind compared with reductionist descriptions.

We must now understand how this applies to the problem of overdetermination. We will stick to case 2, as we did for Strong Emergence, because it causes the most problems in our current paradigm. Let's turn our attention back to the sixth premise stated by Kim, *Non-overdetermination*. In it, we saw how two distinct and individually sufficient cotemporal causes cannot, in his view, cause overdetermination, unless the case fits in with the double-rock-throw variety. Looking at case 2, consider that special-science feature *S*, which contains a proper subset of the powers possessed by base feature *P*, causes a base feature *P**. In this instance we can infer through the *Proper Subset of Powers Condition* that two distinct token features (*P* and *S*), which possess the same token power,

13 Forrest (1996)

14 "For example, *S* might be a Strongly emergent state of being thirsty, which depends on base feature *P*, and which in the circumstances causes a physical reaching for a nearby glass of water *P**."

15 Wilson (2021), pp. 67-68

both participate in the causing of *P**. This case is not of the double-rock-throw variety, since the token powers are not distinct, making it a genuine case of overdetermination, and a genuine reason for rejecting Kim's premise. I'm reporting Wilson's schema for this case below:[16]

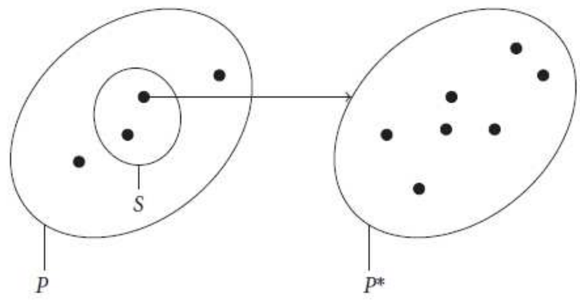

Figure 2.6 The nonreductive physicalist's response to case 2, version 1

As you can tell from the picture, we have just argued for a case where a higher-level feature causes a lower-level one. This is considered problematic by most physicalists, but Wilson proposes a more elaborate solution which allows us to explain *S*'s efficacy. It involves assuming that *S* does not directly cause *P**, but rather the "physically acceptable" goings-on *P'*, which are located a level lower than *S*, but higher than its realizer *P*. Returning to our glass of water, *S* is the mental state which causes the reaching for the glass *P'*, which is also realized by its *P**. The picture for our new relationship is the following:[17]

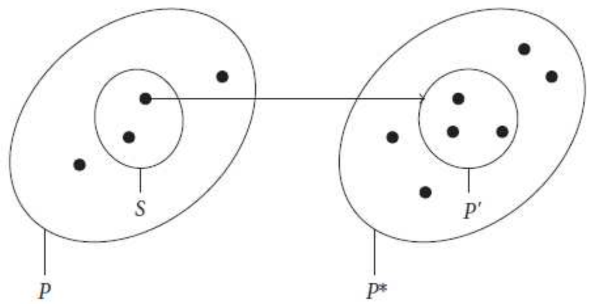

Figure 2.7 The nonreductive physicalist's response to case 2, version 2

In this section we've familiarized with various concepts and arguments within the emergentist framework. We can now briefly address some objections which have been moved towards the concept of Weak Emergence, particularly focusing on its compatibility with reductionism, and on the reality of higher-level features or entities.

16 Wilson (2021), p. 70
17 Wilson (2021), p. 71

2.2 Objections to Weak Emergence

Due to character constraints, we won't be able to include many of the objections that have been raised throughout the years. Still, we can consider two of the arguments Wilson analyses throughout the third chapter of Metaphysical Emergence. We will begin by looking at why Weak Emergence serves as an accurate description of reality, and not only as a pragmatic conceptual tool. Following that, we will be analyzing some concerns about the compatibility of Weak Emergence with reductionism, which will take us to the formulation of the Degrees of Freedom (DOF) account for Weak Emergence.

The first objection we will analyze is taken by Wilson as representative of an Anti-Realist point of view. As hinted above, philosophers such as Ney interpret the *Proper Subset of Powers Condition* as a representational tool: "[One] can […] think of things in the following way (nothing has been said to rule out this way of thinking): on this view, really the mental event (and realized tokens more generally) are just abstractions from concrete microphysical situations. They are abstractions in the sense that they are what we attend to when we focus only on a proper subset of a microphysical state's causal powers."[18]

Heil's Picture Theory provides a schematic account of one might interpret the assumption that an accurate description of a phenomenon gives us a reason for attributing reality to it:

> *The Picture Theory*: When a predicate applies truly to an object, it does so in virtue of designating a property possessed by that object and by every object to which the predicate truly applies (or would apply).[19]

For example, the property of redness, which we would interpret as displayed both by an apple and a strawberry, is actually just a generalization which allows us to track inexact similarities at the lowest level. The same applies, according to Heil, also to any special-science phenomena, such as planets and pain. Essentially, what is argued for is the fact that what we take as real common properties of objects are nothing more than descriptive generalizations.

A first response to these critiques is that at the heart of emergentism lies the will to accommodate descriptions inside our theories, especially considering that the special-sciences do consider the phenomena cited above as being ontologically autonomous. Making sense of complexity requires

18 Ney (2010), In Wilson (2021), p. 76

19 Heil (2003), p. 77

an ontology which is not based on the criterion of parsimony. It is the anti-realist who should provide reasons for why these appearances shouldn't be taken as real. Furthermore, Wilson provides a simple yet brilliant response for why Heil's argument is intrinsically flawed. Even if we were to accept the assumption that higher-level features only keep track of inexact similarities of lower-level features, one might ask why we can't consider them as real. The fact that inexact similarities are not higher-level was not clear before introducing our hypothesis, hence one is free to interpret them as emergent phenomena themselves, which would confer reality back to them.

Another interesting problem is raised by Morris: "[C]an the powers of a mental occurrence really be a subset of the powers of a physical occurrence, if the former is a difference-making cause of certain events while the latter is not? Even if an affirmative answer is possible, talk of mental and physical occurrences only involving a single "causing" becomes strained if mental causes are difference-making causes while physical causes are not—how could a mental occurrence's bringing about some event involve the very same "causing" as some physical occurrence's bringing about that event, if the one is more proportional or difference-making than the other with respect to that event?"[20] In order to answer the question in this passage, we must understand exactly what is intended by difference-making causes, and to do that we will bring one of the favorite examples of emergentist philosophers, pigeons. Imagine two pigeons: one is trained to peck at red patches, the other instead is trained to peck only at a specific shade of red patches, e.g. scarlet. They are both presented a scarlet patch, which both will peck, but for different reasons: while the first one pecks at the patch because it is trained with a general category of red, the second pigeon pecks for a more specific reason (the object is scarlet).This specificity makes the second pigeon's causation a difference-making one in the context of scarlet objects. In Wilson's response, this difference-making is exactly what makes it possible to argue for the entity's causal autonomy.

The higher-level feature, possessing fewer powers than its realizer on the given occasion, means that any changes in powers not common to both the realizer and the realized are irrelevant—they do not impact the outcome. This is why the higher-level feature aligns with difference-making considerations; it is precisely because it is defined by a more selective set of powers, focusing on those that are crucial for the specific effect in question. It is now easily understandable, as we highlighted throughout our discussion on Weak Emergence, that possessing a power and a power profile are two different ways of exhibiting causal efficacy, and while both can exert an influence at the same time, only the power profile is able to track difference-making considerations.

20 Morris (2018) In Wilson (2021), p. 83

Reductionism is also concerned with trying to identify the higher-level feature with its fundamental base. In particular we will explore an objection that sees higher-level features as a metaphysical consequence of the laws present at the lower level. Owens expresses in one sentence the objection we will be analyzing: “Reductionism is sometimes expressed as the thesis that the laws of the non-physical sciences can be deduced from those of the physical sciences together with certain bridging generalizations […].”[21]. This position aligns with an in-principle reductionist view, thus our answer will need to be purely metaphysical. Kim and Morris express similar concerns; the problem here is to ensure once again that our higher level features are not identical to their bases, which is something we argued for earlier, when talking about Leibniz’s Law.

Morris in particular presents an argument which is centered around the notion of Non Fundamental Mentality (NFM), which basically asserts that our universe is wholly composed of physical properties and powers, which is in line with the premises of emergence. From the recognition of the fact that a Weak Emergentist will agree that a higher-level entity will possess a proper subset of powers which are all in line with NFM, he observes: “And if properties are the properties that they are in virtue of their powers, it is difficult to see why a property that has all and only NFM-physical powers should not be regarded as NFM-physical.”[22]. Still, a Weak Emergentist will reject the idea that special-science properties are nothing more than their base-properties. The response presented by Wilson involves the Degrees of Freedom (DOF) account of Weak Emergence. For this reason we will now briefly introduce it, and later see how it can help us in resolving this case.

2.3 Degrees of Freedom

In this section I will be following chapter 5 of Metaphysical Emergence, where Wilson gives a thorough introduction to the concept of DOF and its integration inside the schema for Weak Emergence. First, we can start by reporting the operative notion she gives at the beginning of the paragraph:

> *Degrees of Freedom (DOF)*: For an entity *E*, characteristic state *S*, and set of coordinates *C*, the associated DOF are parameters in a minimal set, expressed in coordinates *C*, needed to characterize *E* as being in *S*.[23]

21 Owens (1989) In Wilson (2021), p. 91.
22 Morris (2018), p.135.
23 Wilson (2021), p. 177.

Let’s now dissect it in its components, starting with states. The three most common states individuated by Wilson are:

1. The *configurational* state, whose purpose is to track the position of one or multiple entities and which requires for each entity three parameters (x, y, z) in order to be expressed.
2. The *kinematic* state, which tracks velocity, and thus needs six parameters, the three of the configurational state plus three which track velocity alongside the coordinates.
3. The *dynamic* state, which tracks energy, and requires at least one parameter per coordinate, in the case of kinetic energy.

The other fundamental premise brought by Wilson is the analysis of which circumstances require reduction, restriction or elimination of the DOF needed to characterize an entity.

I. *Reduction of DOF*: A point particle moving in a plane exemplifies how constraints can reduce its configuration degrees of freedom (DOF) from three to two. This reduction doesn't eliminate the DOF but fixes it at a constant value, effectively simplifying the description without changing the underlying laws. Classical mechanics' treatment of rigid bodies demonstrates this reduction, where the system's DOF is less than that of its individual, unconstrained components.

II. *Restriction of DOF*: *When* a point particle is constrained to a specific region, including and above a plane, it still requires three configuration DOF for an accurate description. However, the range of possible values for one of these DOF is limited. This scenario is akin to molecular bonds acting like springs, where the molecules' DOF is restricted compared to a fully unconstrained system of atoms. The governing laws remain dependent on these specific DOF values, even though they're more constrained than in the unconstrained scenario.

III. *Elimination of DOF*: In some cases, constraints lead to the outright elimination of DOF necessary to describe an entity's state. For instance, a group of N free point particles may form a spherical conductor in electrostatics, which can be characterized with fewer DOF. Here, the entity's properties and behavior become independent of certain DOF that were critical in the unconstrained system. This elimination is seen in the transition from quantum to classical descriptions, where quantum DOF, such as spin, are not required to describe the states of entities in classical mechanics.

It is important to note that any constraints imposed upon an entity must be understood as a consequence of physically acceptable processes, and that the properties of a higher-level entity *E* are determined by the properties of its base e_i, but exclusively when the base entities stand in a relation which is relevant to the composition of *E*. Having introduced these fundamental notions, we can move on to the integration of DOF inside the treatment of Weak Emergence:

> *DOF-based Weak Emergence*: An entity *E* is Weakly emergent from some entities e_i if
> 1. *E* is composed by the e_i, as a result of imposing some constraint(s) on the e_i.
> 2. For some characteristic state *S* of *E*: at least one of the DOF required to characterize the system of unconstrained e_i as being in *S* is eliminated from the DOF required to characterize *E* as being in *S*.
> 3. For every characteristic state *S* of *E*: every reduction, restriction, or elimination in the DOF needed to characterize *E* as being in *S* is associated with e_i-level constraints.
> 4. The law-governed features of *E* are completely determined by the law-governed features of the e_i, when the e_i stand in the relations relevant to their composing *E*.[24]

Considering that we are implementing the DOF in the framework of Weak Emergence, it must ensure that Cotemporal Material Dependence, Physical Causal Closure, Ontological and Causal Autonomy, and the Proper Subset of Powers Condition are all still satisfied. From an analysis of the conditions, we can see that Cotemporal Material Dependence is satisfied by the first one, which also ensures physical monism. Condition four on the other hand, because of the specific role determination has in this case, allows for the satisfaction of Physical Causal Closure. The third condition ensures, as noted above, that any change in DOF happens because of physically acceptable processes. The satisfaction of the other two conditions is obtained thanks to condition two.

Entities emergent under DOF-based Weak Emergence criteria manifest ontological and causal autonomy, predicated on the elimination of specific DOF—such as quantum spin for macro-entities—which are indispensable for the operation of lower-level physical laws (Lp) but are not necessary for the emergent entity's (E) characterization. This elimination signifies that emergent entities cannot be congruently mapped onto any lower-level physical phenomena, as their definitional schema lacks the complete DOF set necessary for lower-level laws to exert influence, thereby proving their

24 Wilson (2021), pp. 179-180.

ontological independence. Concurrently, this ontological distinction provides a sound basis for the causal autonomy of emergent entities, as their influence and interactions in the world are not merely reducible to the sum of lower-level physical interactions.

The emergent entities' causal autonomy is further highlighted through their adherence to the Proper Subset of Powers Condition, a direct consequence of the emergent entities possessing a more constrained set of DOF compared to their constitutive lower-level system. This condition posits that while every causal power possessed by the higher-level entity finds a parallel within the comprehensive power set of the constituent system, it does not inherit the entirety of its base-level constituents' causal capabilities, particularly those associated with eliminated DOF such as quantum spin. This nuanced power profile ensures that emergent entities, though fully determined by the law-governed features of their constituents when configured in compositionally relevant relations, exhibit a distinctively efficacious causal role, not encapsulated by the constituent system's broader power spectrum.

Now that we have cleared any doubts about the viability of Degrees Of Freedom applied through the framework of Weak Emergence, we can finally see how it's applicable in various scenarios, including the response to Morris's argument.

2.3.1 The Applicability of DOF

As we have just confirmed, emergent entities analyzed through the Degrees of Freedom (DOF) framework inherently showcase ontological and causal autonomy, effectively countering Morris's Non Fundamental Mentality (NFM) argument. This autonomy is highlighted by two key aspects:

1. Emergent entities distinguish themselves from lower-level physical phenomena through the selective elimination of specific DOF, such as quantum spin, which are crucial for the operation of lower-level physical laws but unnecessary for characterizing emergent entities. This indicates that emergent entities, by lacking the complete spectrum of DOF, particularly quantum-level information, cannot be directly equated to their physical bases. Such a distinction not only affirms their metaphysical distinctness but also challenges reductionist views by showing that emergent features, while arising from physical laws, do not conform to their requirements, which makes them unanalyzable through them and thus irreducible to their base constituents.
2. Emergent entities possess a unique set of causal powers, defined by a subset of the powers inherent to their constituents but excluding those tied to eliminated DOF. This configuration

> ensures that while emergent entities are influenced by the same physical laws that govern their constituents, they exhibit distinct causal capacities not attributable to any lower-level physical interactions. This causal profile, shaped by the DOF-based Weak Emergence conditions, provides emergent entities with a distinct efficacy in the world, not merely as a sum of their parts but as bearers of unique properties and behaviors.

This refutes Morris's argument, emphasizing that higher-level features, through their ontological and causal autonomy and in the context of physicalism, maintain a unique, irreducible status. This nuanced relationship between emergent entities and physical laws underscores the complexity of emergent phenomena, affirming the autonomy of emergent features against reductionist perspectives.

Speaking of complexity, it is appropriate to draw one more application of DOF-based Weak Emergence from the realm of complex systems, which are a class of phenomena often interpreted as supporting emergentist accounts.

Mitchell, aligning with thinkers like Wimsatt and Kauffman, as we shall later see, argues that emergence in chaotic complex systems, such as bird flocking, results from non-aggregative compositional structures. These structures manifest through dynamic interactions among system components, characterized by feedback loops, leading to self-organized systems. Using bird flocking as an example, Mitchell posits that emergent group behaviors, such as vee formations, cannot be predicted by aggregating individual behaviors but emerge from the complex, non-aggregative interaction among birds. In Mitchell's own words: "The vee pattern that emerges in a flock of geese or the more complex patterns of flocking starlings are not predictable by an aggregation of behaviors of individuals in solo flight, but only from the non-aggregative interaction or self-organizing that derives from the local rules of motion plus feedback among the individuals in group flight (see Couzin 2007; see Rosen 2007 for photos of the starling patterns). Ontologically, there are just physical birds; there is no new substance, no director at a higher level choreographing the artistic patterns the flocks make. Nevertheless, this type of behavior is emergent."[25] While this argument might seem sound, Wilson challenges the sufficiency of non-aggregativity, in a context where it is interpreted as a whole having properties not possessed by its parts, as a basis for claiming the ontological and causal autonomy of emergent features. Reductionists can allow for the novelty of properties in complex configurations, and non-linearity does not preclude their reduction to lower-level physical processes, since nothing prevents a reductionist to take nonlinear lower-level phenomena as an input in

25 Mitchell (2012), p.179

their theorizing. Mitchell also argues for the causal novelty of group-level interactions, on the basis that the emerging properties are stable, and consequently also a target of historical effects such as natural selection. Furthermore, contextual features such as division of labor (through the example of "computer bees") are taken as another proof of novelty. But the reductionist is also free to take these additional facts as inputs, and can thus refute Mitchell's account as simply showing the availability of a pragmatic reading of these phenomena, while still considering them ontologically as nothing more than highly complex lower-level processes.

Wilson proposes the DOF-based Weak Emergence framework as a more robust basis for understanding emergent phenomena. She observes that in flocking behavior, the positions of individual birds within the flock are constrained, reducing the DOF necessary to describe the flock as a whole. Tracking the position of a flock composed of 100 individual birds would, if analyzed one by one, require at least 300 position DOF. In actuality, the birds composing a flock mutually constrain the position of the others, especially by granting that the birds inside the flock will follow those located at the outskirts. Thus, in order to track the flock in this case we will only need to specify the DOF necessary to track the outer birds. This reduction in DOF underpins the ontological distinction and causal efficacy of emergent entities, addressing the shortcomings of Mitchell's account by providing a clear mechanism through which emergent features can be both ontologically and causally autonomous.

In this first chapter my intention has been to provide the fundamental concepts of metaphysical theories of emergence, integrated with some useful examples and applications, in order to understand its primary concerns. We have seen that theories focus primarily on developing schemes useful for categorizing a broad range of phenomena, which must be defensible from multiple objections and in particular those moved from reductionists. The combined effort of the philosophers we have cited, alongside many others, argues for a complex and layered view of our world, where different classes of phenomena are seen as occupying different levels of reality, not just as an epistemic or pragmatic tool. This is by itself an incredible accomplishment, but with it comes a vocabulary which is highly technical, perhaps too much, if we wish for the philosophy of emergence to become a useful tool for those who conduct scientific research. This is why we will now shift our focus to William Wimsatt, a philosopher who throughout his career has always kept a pragmatic approach to the subject, developing theories which can be understood and applied by fallible operators, which would be us humans. As testified by the title of the volume in which he collected most of his papers on the subject, "Re-Engineering Philosophy for Limited Beings, Piecewise Approximations to Reality", we will now move from the metaphysical realm and its wish to find all-encompassing accounts applicable to all of reality, to a primarily epistemological inquiry about our world, which sees our finite condition not as a limit, but instead something which we should always keep at the center of our theories.

3

Exploring the Complexity of Scientific Inquiry Through Wimsatt's Lens

William Wimsatt's contributions illuminate the complexities of scientific inquiry through robustness, reductionism, and heuristics. He proposes robustness as a criterion for evaluating the reliability of scientific theories across varied conditions, arguing that this multiplicity of confirmatory paths enhances a theory's credibility. Wimsatt critiques reductionism for its oversimplification, advocating for a more integrative approach that acknowledges the intricate interplay between different scientific levels. He emphasizes the utility of heuristics as pragmatic tools that guide scientific reasoning, navigating through complexity with rules of thumb that, while not universally applicable, offer valuable starting points for investigation. By comparing and contrasting his views with those presented through Wilson in Chapter 1, this section will delve into Wimsatt's nuanced understanding of emergence, highlighting both synergies and divergences. This exploration not only enriches our grasp of scientific methodologies but also highlights the philosophical contributions that shape our comprehension of the natural world.

3.1 Robustness: An Epistemological Ontology

The concept of robustness has been explored in several key contributions by Wimsatt, starting with his central paper "Robustness, Reliability and Overdetermination" published in 1981.
Its history is almost as old as the history of philosophy, beginning with Aristotle, who was the first to emphasize the importance of providing multiple explanations for a phenomenon. It has initially been revitalized by Pierce in the nineteenth century, who is also one of the founders of emergence. Wimsatt reports a passage where Pierce argues for the necessity of philosophy in imitating what is successful about the special sciences, especially the bringing forth multiple arguments as an explanatory means rather than reducing this multiplicity to a single, conclusive one. This is essentially what robustness is, a means of triangulating the existence of the object of inquiry through as many means as those that are available.

Wimsatt identifies four fundamental procedures to all accounts of robustness[26]:

1. To analyze a variety of independent derivation, identification, or measurement processes.
2. To look for and analyze things which are invariant over or identical in the conclusions or results of these processes.
3. To determine the scope of the processes across which they are invariant and the conditions on which their invariance depends.
4. To analyze and explain any relevant failures of invariance.

What resists this analysis (what remains invariant) is appropriately deemed robust. Clearly this is a general characterization of a method which aims to be applicable to any object of scientific inquiry. For this reason he also provides a list of specific methods, which have been developed by multiple authors, such as the use of different sensory modalities, explanatory procedures, assumptions, models and tests. The use of invariance is emphasized through comparative analysis between: macro-states and a set of applicable micro-states, or theoretical descriptions of the same phenomenon, where a failure of invariance can allow for the development of new hypotheses. Failures of invariance or matching are emphasized as a way for recalibrating our measuring apparatus or tests, for establishing situations in which the failures do or don't present themselves and to analyze component hypotheses of a complex theory.

Despite their diversity, all of these different procedures enter what we call robustness analysis, because they all allow us to pose distinctions between what is ontologically and epistemologically reliable from that which is ungenerizable and fleeting. What must be common to any application of robustness is the use of multiple and independent processes which, if applied correctly, will provide the best available means of avoiding illusions. As Wimsatt puts it: "Robustness even has the right metaphysical and epistemological properties. Thus it is part of our concept of an object that objects have a multiplicity of properties. But different properties will generally require different kinds of tests or procedures for their determination or measurement. Thus it follows that our concept of an object is a concept of something which is knowable robustly. Indeed, one of the ways in which we detect illusions is that appearances to one sensory modality are not borne out with the appropriate confirmation in the other sensory modalities - confirming, for a visual hallucination or mirage that what we see before us is not an object, not real."[27].

26 Wimsatt (1981), p. 2
27 Wimsatt (1994), p.10

Now that we have a general idea of what robustness is about, we can begin looking at some ways presented by Wimsatt in which it can be applied to different areas of scientific inquiry, starting with the structure of theories.

3.1.1 Identifying a Robust Structure of Theories

In his critique of the current structure of physical theories, Wimsatt follows Nobel prize winner Richard Feynman's distinction between the "Greek" and the "Babylonian" approach, presented in his essay "The Character of Physical Law". The Greek or Euclidean approach is the one we usually associate with mathematical and physical theory. It consists in presenting a minimal set of assumptions from which everything else is to be derived. The reduction of the number of assumptions usually happens a posteriori, when the theorem has already been formulated.

In contrast, the Babylonian approach is characterized by a more flexible and interconnected understanding of theories. It does not strictly adhere to a linear progression from axioms but instead works with a variety of known elements, reconstructing the theoretical framework as needed. This method acknowledges the complexity and rich connectivity within mathematical and physical laws, allowing for a dynamic and adaptable understanding of theories. It embraces the idea that fundamental laws and theorems can be derived from multiple starting points, reflecting the intricately connected nature of knowledge. Wimsatt inteprets Feynman as suggesting that the most fundamental laws might be those that can be independently derived in a variety of ways, indicating a deeper level of fundamentality based on the flexibility of derivation. This should ring a bell, as you will remember that independent derivability is one of the criteria for identifying what is robust.

Secondly, Feynman points out the practical advantage of the Babylonian approach in scientific inquiry. The interconnectedness and multiple derivability of laws make the theoretical structure more resilient to errors or changes. If a part of the theory proves to be incorrect, the structure can be adjusted without collapsing entirely, as alternative derivations and interpretations can uphold the theory's validity. This resilience is crucial in the dynamic and evolving nature of scientific understanding, where theories are constantly tested, refined, and sometimes revised. In relation to this, Wimsatt notes that if some components of the theory seem the least subject to change, they will in all likelyhood be the most fundamental and robust.

Through the statistical theory of reliability, he provides a compelling reason for adopting the Babylonian approach. The Greek approach seeks to establish theories based on minimal and certain assumptions, operated upon with highly reliable deductive rules. The goal of this approach is to eliminate error entirely, creating a system where, theoretically, if the assumptions and rules are error-free, the resulting theory should also be error-free. However, Wimsatt identifies the limitations of this approach by considering that it is humans who have to apply it. By modeling a real scenario where operations (choosing assumptions or applying rules) carry a small but finite probability of error, he demonstrates that longer deductive chains have an increasing probability of failure. This is due to the cumulative effect of the error probability in each step of the chain, highlighting a fundamental weakness in long serial reasoning processes.

In contrast, he proposes as alternative model, parallel organization, where having independent alternative ways of deriving a result significantly increases the reliability of the conclusion. This approach, likened to redundancy in engineering or biological systems, ensures that the overall structure remains robust even if individual components fail. The redundancy allows for multiple paths to a conclusion, consequently enhancing the reliability and resilience of the theoretical structure. As we hinted earlier, theories often undergo a process of “Euclideanization”, which consists in removing redundant assumptions to achieve elegance and simplicity. This process, while making the theory appear more elegant, actually increases its vulnerability to errors. By reducing redundancy, it lengthens the chain of deduction and decreases the number of alternative paths to a conclusion, both of which cumulatively increase the probability of failure and the severity of its consequences. A direct example of the efficacy of the Babylonian approach, which also testifies its implicit use in many scientific domains, pertains to the handling of inconsistencies within scientific theories, challenging the notion that contradictions lead to total collapse. It suggests that scientific theories are more robust than this, with inconsistencies often being localized and not affecting the theory's overall integrity. This resilience is attributed to the robustness provided by redundant, alternative support for assumptions, which prevents a total collapse even when inconsistencies are present.

In essence, the Babylonian approach to scientific theorizing, with its multiple connectedness and redundant structures offers a more reliable and resilient framework for dealing with the inherent fallibility of human reasoning and the complex nature of scientific inquiry. This approach recognizes the value of redundancy, parallel paths, and the robust handling of errors and inconsistencies, contrasting sharply with the more rigid, error-averse axiomatic method.

This application of robustness analysis provides a direct perspective on Wimsatt’s approach to the problems of scientific theorizing. As you can tell, he proposes alternative solutions which are broadly utilizable and are based on the cognition of the human actor as limited. Let’s now look at a second application of robustness analysis, which directly pertains to the contents of this dissertation.

3.1.2 The Identification Of Levels Of Organization

Wimsatt's robustness analysis plays a crucial role in the identification of levels of organization. Throughout his works, we often find a saying by Plato in his works which says that “the goal of science is to cut up nature at its joints”; he argues that levels must be then natures major vertebrae.

He employs Campbell's criteria to argue for the autonomy of different levels of organization based on their causal relationships and robustness. Entities at a particular level primarily interact with others at the same level, forming a robust network that justifies treating each level as dynamically, ontologically, and epistemologically autonomous. He calls this in another fundamental paper a kind of “panphenomenalism”: “[…] at which entities and things detected by them at different levels are equally real, and none is secondary, in its reality, to any other. This is, I think, a necessary move in removing the feeling of austerity that many people appear to fear in reductionism—what, in other words, might be called the "nothing more than" phobia.”[28]

By acknowledging the robust connections among entities within the same level, the discussion reinforces the idea that higher-level phenomena retain their significance and explanatory power (they are not “analyzed away”) even when examined through the lens of reductionistic science.

In order to understand what is different in his perspective on levels of organization, Wimsatt introduces Levins' concept of the “Sufficient parameter”. Sufficient parameters streamline complexity by grouping many lower-level variables into a smaller, more manageable set of higher-level variables, allowing scientists to focus on key indicators that highlight broader trends or behaviors of a system. These parameters effectively capture the essence of important information about upper-level phenomena, summarizing the impact of significant variations in detailed lower-level variables. This aggregation process, however, introduces a level of imprecision due to its many-to-one nature, making it difficult to discern specific lower-level phenomena contributing to upper-level states.

The concept is crucial for modeling and explaining phenomena across different levels of organization, providing a powerful tool for abstracting and simplifying complex interactions into more manageable terms. Despite the imprecision introduced by this aggregation, it acknowledges the inherent complexity and interdependence of natural systems, allowing for a coarser, yet more generalized description of the system. This results in fewer distinguishable upper-level state descriptions compared to the detailed lower-level descriptions, introducing a degree of imprecision. This imprecision, while potentially concerning to philosophers who prioritize “in principle” describability, is un-

28 Wimsatt (1976), p.38

avoidable and necessary for the application of concepts by actual scientists, given our limited computational power.

In light of this, robustness becomes a crucial concept. It ensures that upper-level phenomena—despite the underlying complexity—maintain stability and are relatively insulated from fluctuations at lower levels, granting them a form of dynamic and explanatory autonomy. This autonomy implies that changes in micro-states often do not significantly impact macro-level outcomes, highlighting the causal efficacy of macro-level variables over their micro-level counterparts. Such a perspective underscores a nuanced view of causation, emphasizing manipulability and the practical implications of selecting explanatory levels, which aligns with the computational and pragmatic considerations in scientific modeling and inquiry.

As you probably have noticed, the concept of sufficient parameter resembles closely that of DOF, introduced in chapter 1. We will save our comparative analysis for later. As is typical of Wimsatt, this framework offers a compelling perspective on how to navigate the intricacies of natural systems, emphasizing the importance of practicality, adaptability, and the constant pursuit of understanding in the face of complexity.

3.2 Heuristics and Reductionism: A Complementary View

In this section I will briefly outline the concepts of heuristics and reductionism as employed by Wimsatt, and show how the employment of the concept of reductionism found in his works transforms it from a bias present in the work of many philosophers of science into a powerful methodological tool. Throughout this section it will become evident that reductionism itself is to be employed as a heuristic procedure, but first, we need some introductory background.

3.2.1 The Concept of Heuristics

In this introduction to heuristics we will be following chapter 5 of “Re-Engineering Philosophy for Limited Beings”, titled “Heuristics and the Study of Human Behavior”. In it he provides a general description of the concept of heuristics, and how they can be employed in the identification of the biases of reductionist research strategies.

Heuristics are introduced as a methodology in the study of systems which go beyond our power of analysis. Here, they serve as a way of introducing idealizations and approximations, in order to go from an unapproachable problem to one which lends itself to be properly analyzed. He outlines four fundamental properties of heuristics:[29]

1. The difference between heuristics and truth-preserving algorithms (such as the axiomatic theory structure we saw in the previous section) are that they make no guarantee of producing a correct solution for a given problem. Heuristics may be applied correctly to correct input information and still produce wrong results.
2. The reason for the employment of heuristics is that they are a “cost-effective” strategy in terms of computation.
3. They produce errors which are systematically biased. This entails that they will break down in specific sets of cases, but not randomly, making it possible to predict the cases in which they won’t function. Furthermore, in those cases in which it is appropriate to speak of direction of error (the overestimation or underestimation of the true value or probability of an outcome), they will cause errors in a certain direction.
4. The generation of a heuristic for a problem will give rise to a related, but non-equivalent problem. This entails that answers to the heuristic might not be directly corresponding to answers to the original problem.

As you can tell this is a fundamentally different perspective to the resolution of scientific problems compared with the traditional reductionistic methods presupposed by philosophers of science. For Wimsatt, it its imperative to avoid any talk about in principle analyzability or deducibility, because it masks a transition from the figure of the scientist to that of an omniscient being. He considers this kind of equiparation not only useless for any practicing scientist, but also a main reason for why many scientists have over the years developed a disdain for philosophy. Instead he argues for a model of the scientist in which they must “[…] consider the size of computations, the cost of data collection, and must regard both processes as “noisy” or error-prone.”[30]

In order to further clear up the functioning of heuristic procedures, we can examine the comparison drawn by Wimsatt between heuristic procedures and biological adaptations. The four same properties we discussed earlier can be reformulated through this lens:

1. Even when adaptations function as intended, they do not ensure an organism's survival or its ability to produce offspring.
2. Despite not guaranteeing survival, adaptations are cost-effective strategies that contribute towards the goal of survival and reproduction.

29 Wimsatt (2007), p.76
30 Wimsatt (2007), p.78

3. Every adaptation has specific conditions under which its use may actually reduce the fitness of the organism. These conditions are rare in the organism's normal environments, as prevalent conditions leading to decreased fitness would result in the adaptation being considered maladaptive and thus being selected against.
4. Adaptations simplify complex computational problems regarding the environment into simpler problems. The solutions to these simplified problems usually provide a reliable guide for addressing the more complex original problems. The most common example is the seasonal changes of behavior and morphology exhibited by plants and animals in correspondence to atmospheric conditions and day light, which of course are potentially skewed in laboratory conditions.

Point three of our heuristics property list is especially important in the study of our reasoning processes. Through the analysis of failure conditions we are able to recalibrate our heuristic. Moreover the opposite can apply, meaning that the occurrence of systematic errors can indicate the presence of a hidden heuristic. This in turn allows for the recognition of the character of the reasoning processes applied to the problem in question, which will facilitate its analysis and possibly evidence biases. This property has been applied by Wimsatt in his famous study "Reductionist Research Strategies and Their Biases in the Units of Selection Controversy”.

Now that the concept of heuristics has been cleared, we must highlight how Wimsatt’s approach to reductionism differs from typical accounts.

3.2.2 The Reductionist Paradigm Shift

Wimsatt’s perspective on reductionism is radically different from those we have seen in the arguments against Weak Emergence analyzed in chapter 1 for two main reasons: the first, which has already been introduced throughout this chapter, is that he argues for a complete refusal of “in principle” positions, which have mostly an ontological character; the second is that his analysis is both philosophical and scientific, thus most instances in which he speaks about the role of reductionism in scientific research he is talking about a conceptual tool, to be heuristically employed.

His philosophical stance on reductionism is most evident in his “Reductionism, Levels Of Organization, and the Mind Body Problem”, published in 1976. In this paper, he confronts Dr. Roger W. Sperry’s position on the status of mental features, which Sperry sees as generated by an “emergent interactionism”. The main question Wimsatt tries to answer through this confrontation is whether it is possible to be both reductionists and emergentists. We shall now see why it is indeed possible.

Wimsatt's critique of traditional reductionism centers on its excessive emphasis on structure—logical schemas, formal systems, and deductive methods—while neglecting the functional aspects of scientific inquiry. He challenges directly the positivistic tradition in philosophy of science, which has unequivocally prioritized structure over function, resulting in a narrow understanding of scientific theories and reductions. He also confronts the notion that the reduced theory is inherently inferior or that higher-level phenomena are simply "nothing more than" their lower-level counterparts, by arguing that this perspective leads to a flawed view of scientific progress, aiming for ontological simplicity without considering the functional diversity of reductions. Instead, he calls for a distinction between different types of reductions, emphasizing that not all reductions serve the same purpose nor should they be treated as mere deductions. In particular, he poses a fundamental distinction between the role of intralevel and interlevel reductions.

3.2.3 Intralevel Reductions

The characterization Wimsatt gives of intralevel reductions diverges significantly from traditional views, still popular at the time of publication, that typically characterize scientific progress as a linear evolution, where new theories outright replace and negate older ones. Instead it advocates for understanding the relationship between successive theories not as one of simple replacement but as a more intricate process of transformation and approximation under specific conditions. This approach is largely inspired by Thomas Nickles's insights, which argue that the interaction between theories—such as the relationship between classical mechanics and relativistic mechanics—is not purely eliminative but serves heuristic and justificatory functions, illustrating how one theory can be considered a special case of another in certain limits.

One of the core arguments for the utility of intralevel reductions is their role in justification. Rather than outright rejecting the predecessor theory, intralevel reductions serve to validate the new theory by demonstrating its compatibility with the evidence that previously supported the old theory. While specific conditions are required for this approximation, this aspect of reduction plays an important role in arguing against the notion of abrupt discontinuities in scientific progress, which were popularized in the previous decade by philosophers such as Kuhn and Feyerabend. Another important feature is that they allow us to delineate the scope and limitations of the old theory, establishing it as a valid approximation within a certain range. This facilitates its use as a heuristic tool for prediction and calculation in scenarios where the old theory might be simpler to apply than the new, more comprehensive theory. What this entails is that in the practical application of scientific theories, we can still identify conditions in which the old theory (which is often simpler) can be successfully applied. One last significant advantage of intralevel reductions is that they provide a way for testing and elaborating new theories through the identification of unreduced differences. These differences, which may have presented as anomalies under the old theory, offer a critical test for the new theory, which must account for these discrepancies to be considered valid. Furthermore, the process of reduction can uncover previously unanticipated differences, providing new ways for predictive tests and theoretical development. This process of refinement and expansion upon previous theories is crucial for the advancement of scientific knowledge. These applications of intra-level reductions echo what we said earlier about the Babylonian approach to theory construction: drawing comparisons between theories, identifying when they succeed and when they fail and utilizing this information to build new ones are all heuristic procedures grounded in robustness.

Wimsatt delineates also the conditions in which intralevel reductions might not be applicable. The concept of incomparability arises when the similarities and differences between two theories cannot be clearly specified or isolated, leading to a situation where meaningful comparison becomes impossible. This often occurs when the accumulation of differences and the complexity of transformations between theories go beyond a manageable threshold, highlighting a potential failure point in the process of reduction. Additionally, the intransitivity of intralevel reductions suggests that while a series of reductions might connect successive theories, there eventually comes a point where the relationship between theories shifts from reduction to replacement. What differs from Wimsatt's account of incomparability from the traditional ones is that they are focused on the meaning change of key terms present in the two theories. On the other hand, he notes that meaning change is significant in those cases where it has become unlocalizable: "Meaning change, if it is localizable to specific terms and analyzable in its effects, is just one more difference that must be considered in comparing the two theories-not a special kind of difference that makes reduction impossible."[31].

3.2.4 Interlevel Reductions

Wimsatt notes that the distinction between intra and interlevel reduction is not present in the literature of his time. As we have seen, the traditional reductionist view assumes a straightforward mapping between theories of different levels (e.g., psychological and physiological, Mendelian and molecular genetics). Instead he argues, based on thinkers like Taylor and Hull, that such mappings are often not possible due to the complexity or absence of direct correspondences between terms or

31 Wimsatt (1976), p.14

entities across levels. This complexity challenges the notion that higher-level phenomena can be fully explained by lower-level mechanisms through simple translations or one-to-one mappings.

He cites Hull's analysis of genetic epistasis, which illustrates that genetic interactions at the Mendelian level cannot be directly reduced to molecular mechanisms without considering the entire molecular context. Hull concludes his paper by saying that “If the logical empiricist analysis of reduction is correct, then Mendelian genetics cannot be reduced to molecular genetics. The long-awaited reduction of a biological theory to physics and chemistry turns out not to be a case of "reduction" after all but an example of replacement. But given our pre-analytic intuitions about reduction, it *is* a case of reduction, a paradigm case.”[32]. Wimsatt notes that Hull’s claim does not imply an impossibility of explaining higher-level phenomena at the lower level because of some kind of fundamental novelty seen in strong emergentist positions. The problem instead is that interlevel reduction should be viewed not as a straightforward translation or a direct relation between theories but as a more nuanced relationship that acknowledges the complexity of mapping between levels. On this basis, he notes two main reasons why interlevel reduction should be considered as different from both intralevel and typical accounts of reduction: first, it does not offer any kind of translation; second, it cannot be considered as a relation between theories or parts of theories.

Wimsatt brings foreward three different reasons for why interlevel reduction is not interpretable as a translation. The first reason is that translations in science, as in foreign languages, are highly context dependent. This is made evident by the fact that any attempt of drawing one-one or many-one correspondences requires an integration of milieus which stand in the middle between those that are being translated. As we noted multiple times, the fact that these translations are possible in principle, cannot be considered a valid argument for their actual realization, or for setting them as a goal. Furthermore, translations or type correspondences are transitive, meaning that in the reduction from the social level to the atomic we will have to move through multiple realms, and our end result won’t have any explanatory value. As Sperry puts it “eventually everything is held to be explainable in terms of essentially nothing”. Intralevel reductions offer real translations because of their intransitive quality. Finally, interlevel reductions should in principle allow for a replacement of the reduced theory, but the increasing difficulty of translation makes it evident that it is actually irreplaceable. This is because we need practical instruments for dealing with regularities at given levels, and an all-encompassing theory would become too complicated or abstruse to have any practical value. Returning to Hull’s passage, Wimsatt criticizes the idea that molecular genetics will be substituting

32 Hull (1974), p.44

Mendelian genetics, for the simple reason that they serve different useful purposes in their given applications.

It is easy to see how the failure of translation challenges in turn the idea that interlevel reduction involves a relation between theories or parts of them, widening the gap with the intralevel counterpart. In particular, the complexity of this kind of reduction makes us give up a deductive relation between types. As you will remember from the first part, types refer to general categories, while tokens represent specific events. What this implies is that referring to particular phenomena in order to make a reduction is mutually exclusive with the possibility that the reduction is a relation between theories, which only include types in their formulations. On this basis, we can also criticize the claim that lower-level theories explain the higher-level one in a reduction. Not being able to construct type relationships between theories challenges this explainability claim because often higher-level categories do not possess lower-level unity. If we cannot explain why the categories of a theory behave in a certain way, the original claim fails. Finally if there are no clear type correspondences, versions of the identity theory which claim that higher-level properties are individually identified with lower-level ones also fail.

Interlevel reduction is regarded by Wimsatt as "an explanatory relation between lower level theory or domain of phenomena and a domain […] of upper-level phenomena"[33]. Another endorsed proposal is that of Roth: especially in cases where upper-level categories are partially explained, we might interpret the reduction relationship as a development of an interlevel theory.

3.2.5 Explanation and Identification

Common accounts might suppose that identification of phenomena between levels can serve as a basis for arguments supporting ontological simplicity, and utilize reduction for this end. Wimsatt proposes an opposite view "*identification can be seen as a tool in the service of reduction, and the interesting dividends of interlevel reduction in general,* […] *are explanatory rather than ontological."*[34]. The absence of type identity leaves us only with the possibility of working with token identity. Wimsatt sees the value of this kind of identity in the explanatory power it possesses, by noting that any upper-level phenomena in need of an explanation can possibly find it at the lower level. Identity claims should serve as a heuristic for identifying explanatory failures. In cases where the identification is inexact, like in intralevel reductions, errors will accumulate, leading for example to false predictions or leaving some phenomena unexplained. Through Leibniz's law, which we saw

33 Wimsatt (1976), p.20
34 Wimsatt (1976), p.21

earlier, we can go deeper in levels of description until we can find something which has violated the identity relation. This in turn will probably be the source of our explanatory anomaly.

Wimsatt employs this hypothesis as a way of explaining the reason for some of the problematic claims we saw earlier:

1. The reason for positing in principle translatability might stem from the application of Leibniz's Law for two levels of descriptions applied to the same objects. A property which is applicable to different levels will need to have a translation at both levels in question. A failure of translatability will highlight any differences present in the application.
2. Identity relations might at first seem trivial, only implying coreferentiality between objects. This is not true, because in fact any anomaly arising from this coreferentiality will be explanatory.
3. Identity claims cannot be seen as the goal of reduction, because if it were so they would be made only in instances where all relevant information has been found. In actual fact, they are made and refined through the process of investigation because of their explanatory value.

As an example of the efficacy of the identification of differences for finding explanatory failures Wimsatt says: “The nonspatiality of the mental realm […] is not relevant to the argument that the mental is not physical until it is argued that this nonspatiality does not admit of a physical explanation, or is responsible for some other feature of the mental realm which does not admit of a physical explanation.”[35].

3.3 The Ontology, Epistemology and Methodology of Emergence

3.3.1 Levels Of Organization and the Direction of Explanation

Let's finally delve into the characterization of emergence provided by Wimsatt. We will begin by looking at how Levels Of Organization are characterized. In our earlier analysis of robustness we saw the metaphor that nature needs to be cut at its joints in order to be understood. If nature does in fact possess them, “then explanatory ontological, systematic, and controlling aims of science all co-

35 Wimsatt (1976), p. 25

incide at the importance of finding these "joints," and of describing the units in between and how they articulate."[36].

An initial methodology for the identification of different levels of organization is simply the consideration of the size of various entities. For example, the laws of electrical fields do not apply directly to macro-entities. Of course this is not the only relationship that comes into play, like in the case of dust and bacteria, which are of similar sizes but exhibit radically different properties. Still, it allows us to posit that levels are where we find a cluster of similar sized entities, which in turn allows us to characterize them as a maxima of predictability and regularity. Going up in levels reduces the number of Degrees Of Freedom, which provides a reason for why we will find most entities at lower-size scales. Furthermore, if we take the evolution of organisms under selection mechanisms as an example, we will see that they as well can constitute a maxima of predictability and regularity, in the sense that most organisms will be concentrating near a level of organization. Also physical entities such as atoms and molecules concentrate at their levels of organization because they are the *most probable* states of matter under certain ranges of conditions, paralleling the selection processes present for organisms. But levels are not abstract features of a space which don't interact with the systems they are included in. On the contrary, Wimsatt argues for their description as functions of the kinds of systems present in this space, where entities at multiple levels interact and influence each other, reinforcing the entification near a given level. Of course, a system can be singular only at its given level; if we go lower, we will find multiple systems interacting ecologically in it, and if we go higher it will appear as a part of a larger system. The role of robustness is implicit in our discussion of the identification of levels so far, consider the level as the subject of robustness analysis and the entification and interactions will be our independent variables which reinforce this supposition. Ontologically, Wimsatt sees the reality of the entities and properties present at a level justified through the fact that they are reliably detected by other entities at that level. He calls this ontological process the definition of degrees of reality, where something is real when it can be "reliably detected by a reliable detector".[37]. This reminds us of what we said about levels in the section dedicated to robustness.

Explanation plays a fundamental role in this context. Wimsatt starts by noting that we have a reductionist bias towards the direction of explanation. He supposes that it arises from the feeling of asymmetry we get when considering higher-level entities as composed by their lower-level counterparts. But he notes, nothing prevents us in general to invert this relationship, by saying that the lower-

36 Wimsatt (1976), p. 33

37 Wimsatt (1976), p.38

level entities are parts of a higher-level one. What this entails is that the relationship is actually symmetric, until we find some reason for preferring compositional over contextual information. In our common conceptual scheme we will look for a reason for the behavior of a higher-level entity by analyzing its constituents. In other words, the direction of explanatory primacy is from parts to wholes. This bias has a fundamental influence in our conceptualization of science: for theories, we will tend to regard the lower-level ones as more general; in relation to meaning change inside scientific concepts, the lower-level will influence the conceptualization of the higher-level, such as in the relationship between DNA and genes. While these might seem like unquestionable relations, there have been occurrences where the opposite has applied, like the redefinition of the concept of fitness from being applied to an individual to an instrument used for describing entire populations. Wimsatt argues that "explanatory priority seems to account for an appreciable proportion of the sometimes quite obnoxious behavior of an ardent reductionist. But to see this is also to see that such behavior is really ontologically quite innocuous, though some reductionists mistakenly believe otherwise."[38]. He brings an example from the realm of biological evolution for defending the claims made above, which also allows us to get a new perspective on the themes of multiple realizability and downwards causation seen in chapter 1.

He argues that in this field there are often legitimate explanations for the occurrence of a phenomenon both from higher and lower-level sources. In order to explain the particular configuration and composition of the jaws of a soldier termite, we will need to understand not only how it has developed, but also why. A lower-level explanation will answer our how question by talking in molecular and developmental terms about the genetic and environmental factors that lead to its development. On the contrary, answering why it has developed involves a higher level explanation, which Wimsatt formulates in selectionist terms: "The jaws of the soldier termite (which are so outsized that the termite cannot use its jaws to feed itself and must be fed by other worker termites) are specialized for defense and combat with ants, beetles or other potential enemies of the hive. This adaptation and the correlative (colony defending) specialized behavior results in a differential advantage: those colonies that fared better because of it left more "offspring" colonies than those that lacked it and any heritable behaviors responsible for their having fared better were also passed on. The accumulation of such heritable favorable differences leads to the high degree of functional efficiency observed in nature, and in particular to the outsized jaws of soldier termites."[39].

38 Wimsatt (1976), p. 43
39 Wimsatt (1976), p. 43

From such a description it becomes evident that downward causation is a perfectly justifiable concept. In this case, the organizational effects of the division of labor inside the colony are unproblematically taken as being a cause for the modification of the DNA of the termites, in a way which seems more compatible with Strong Emergence. I say this because the scheme provided by Wilson for case 2 would be able to account for the formation of the jaw, but not for the DNA modifications. Still, a Weak Emergentist could argue that higher-level causal efficacy is constitutive rather than autonomous. That is, higher-level phenomena (like termite colony behavior) constitute a pattern of lower-level phenomena (genetic, molecular, and environmental interactions) that have causal efficacy. The feedback loop does not introduce a new kind of causation but is a way to describe how patterns of activity at one level of analysis can influence patterns at another level, all within a unified physicalist framework. Anyway, in Wimsatt's account, this is a testimony of the existence of selection forces happening at the higher-level which can have lower-level effects.

We have here presented some reasons for assuming the ontological reality of levels of organization, alongside their relationship with explanatory considerations. Keep in mind that in our account explanations also play an ontological role, given that we are assuming robustness as our criterion.

3.3.2 The Ontology of Complex Systems

We have finally arrived at Wimsatt's seminal work dedicated specifically to ontology. Before diving into specific topics, we must see which methodological criteria are adopted. Wimsatt's analysis is first and foremost based on the recognition of the robustness of the levels of organization themselves, as well as the entities that compose it. Thus, many of the arguments presented will have a heuristic character, and none of them will seem definitive taken individually, representing tendencies instead of universal statements. The analysis will also rest on a criterion employed by both Wimsatt and Wilson: we should base our analysis on the world we experience, and ontological simplicity is something that needs justification inside of specific contexts, not our end goal. Or, as Wilson puts it: "An adequate account of metaphysical emergence should make natural (straightforward, default) and realistic sense of the appearances of metaphysical emergence, in the absence of specific reasons to think that this cannot be done."[40]. Additionally, Wimsatt considers that from an ontological point of view the "primary working matter" of our world are causal relationships, which can manifest in this account in three different forms: the simpler relationships form larger patterns which, as we have already introduced, are levels of organization. But things can get more compli-

40 Wilson (2021), p. 36

cated, and in cases where there is no single point of view which can account for the complexity of the relations he speaks of perspectives, because we need to access this bulk of causal relationships through systematic slices. In cases which none of these approaches are available he speaks instead of "causal thickets".

As is now evident, Wimsatt's approach is multi-faceted, and he doesn't feel the need to stick to a specific school of thought. So we shouldn't be surprised when he says that: "As a species of reductionist, I want to get as much as I can about higher levels from the properties of lower ones. As a species of holist, it is tempting to try to do the reverse – and for evolving systems, it is not controversial to argue that the arrangement of lower-level parts (and consequently the appearance of certain higher level phenomena) is a product of higher level selection forces. And you can do both at the same time (and we do) as long as you don't commit yourself to saying that the system you study is to be exhaustively characterized by one approach or the other, but regard them as complementary. So it is possible to be a reductionist and a holist too – but not any kind of reductionist, or holist. Unlike an eliminative reductionist, I think that we add knowledge of both the upper level and the lower level by constructing a reduction. We add to the richness of reality by recognizing these linkages - we do not subtract from it. Eliminativists generally worry too much about the possibility of error at the upper level, and not enough about how stable and resilient - how robust - most upper-level phenomena are, a fact that can make the upper-level details more revealing under some conditions than the lower-level ones."[41].

Keeping in mind what we said in the previous section, let's look deeper in the consequences brought by considering levels as a "local maxima of regularity and predictability in the phase space of alternative modes of organization of matter".[42]. He arrives at this formulation through the considerations that most entities will interact directly with other entities present at the same level of organization. This has first of all an epistemological consequence, because these regularities will receive their best explanation in terms of the language appropriate to their level, but we can extend our analysis to the ontological realm by noting that, if our presuppositions are correct, the recognition of stronger interactions between same level entities, alongside the recognition of weaker interactions with entities placed at other levels, serves as a basis for asserting their reality. Extending the view we mentioned earlier, the fact that entities at the same level are "reliably detected by a reliable detector", and that they causally interact more strongly with these detectors, is a prima facie robust motivation for attributing to them an autonomous ontological character.

41 Wimsatt (1994), pp.21-22
42 Wimsatt (1994), p.34

In our previous discussion of inter-level reductions, we briefly illustrated some reasons for viewing them as a process of development of inter-level theories. Wimsatt shows how this view is not only applicable to our conceptual schemes, but also to levels themselves. As we noted earlier, lower-levels of organization are more densely occupied, and by going up in level the scarcity generally increases (on a cosmological scale we will have the fewest amount of entities). The relationship between the entities that compose a level and the level itself is dialectical, and the evolution is similar to that of an ecosystem: “it evolves as a product of the evolutionary trajectories of the entities that compose it, and provides selection forces that guide their evolution (by affecting what is stable). From the evolutionary perspective, levels define niches for their composing entities, but these are coevolving niches which are products of the entities which make up the levels.”[43]. This perspective on levels allows us to dismiss the claim that the entities present in various levels should be regarded as compositionally defined. In order to get an entity it is not sufficient to take various parts and put them together, or in other words, they are not the product of simple aggregativity. The process of coevolution, while still depending on the material base cotemporally (which puts this conception in line with physicalist positions), makes entites and levels exhibit complex characteristics, which support the idea that they are not straightforwardly reducible.

Emergence and Reductionism: A Complementary View

Wimsatt expands the idea of emergence as a non-aggregative process in various papers. We will be particularly focusing on “Aggregativity: Reductive Heuristics for Finding Emergence”. In the first chapter of this dissertation we saw how Wilson deals with the theme of non-aggregativity. She posited that this position is not sufficient in dealing with reductionism, and thus proposed her Degrees Of Freedom account in order to underscore the ontological of causal autonomy of complex-systems entities. Wimsatt would probably agree with her position, but argue that reductionism and emergence are not mutually exclusive concepts. In his own words: “An emergent property is roughly a system property which is dependent upon the mode of organization of the system's parts. This compatible with reductionism, and also common. Too weak for most antireductionists, it is still a powerful tool: characterizing what it is for something to depend on the organization of a system's parts provides heuristic ways of evaluating decompositions which can help us to understand why some decompositions are preferred over others, and why we may nonetheless overestimate their powers. Antireductionists should welcome it as an effective means for clearing away the many

43 Wimsatt (1994), p. 40

cases often called emergent to see what is left, allowing a more focused discussion. And when they see what it can do, some may feel that this kind of emergence is enough."[44]. Let's follow Wimsatt's suggestion, and try to understand how this view can lead us to a concept of emergence compatible with reductionism. Note that speaking on dependence on the organization of the parts implies the fact that emergent properties are context-sensitive, whether intra- or extra-systemic. Despite the complexity, even the extension of boundaries of our system, and the analysis of the relation of its external properties with the broader context can be compatible with a mechanistic explanation. Still, in his account, most of the properties we see as emergent do lend themselves to this kind of analysis. In order to understand why we should accept such an account, we have to introduce the notion of aggregativity (and by contrast, non-aggregativity) more thoroughly.

Wimsatt lays out four conditions for a system to be considered aggregative. In other words, these conditions aim to delineate the circumstances under which a system's properties can be fully accounted for by its constituent parts without reference to the interactions between those parts.

1. Intersubstitution Invariance: This condition posits that parts of the system can be substituted for one another without affecting the overall behavior or properties of the system. It challenges the notion of uniqueness and specificity in component function, suggesting that a high degree of redundancy or uniformity in part function is a hallmark of aggregativity.
2. Size Scaling: The second condition implies that the properties of the system scale linearly with its size. This suggests that doubling the number of components in a system would simply double the system's overall properties or behaviors, indicating a straightforward, additive relationship between the size of the system and its overall characteristics.
3. Decomposition and Reaggregation Invariance: This condition requires that a system can be decomposed into its constituent parts and then reassembled without loss of function or alteration of its properties. This condition speaks to the modular nature of aggregative systems, where the whole is precisely the sum of its parts.
4. Absence of Cooperative or Inhibitory Interactions Among Parts: The final condition stipulates that the system's parts do not engage in non-linear interactions that significantly alter the system's behavior or properties. This condition asserts that for a system to be considered aggregative, its components must operate independently of one another, without synergistic or antagonistic interactions that could give rise to emergent properties.

44 Wimsatt (1997), p. 3

The consequences of these conditions are significant. They provide a framework for assessing the degree to which a system's properties are emergent or can be reduced to the properties of its parts. Systems that meet all four conditions are considered fully aggregative, suggesting that their overall behaviors and properties can be predicted from the behaviors and properties of their individual components. However, the rarity of systems that satisfy these stringent conditions highlights the prevalence of emergent properties in complex systems. The reason for why we intuitively think that there are many entities that are aggregative, is because we pose constraints on how the parts of the systems should be decomposed and rearranged. Wimsatt provides a thorough example in which he highlights the non-aggregativity of circuits, which modify the potency of their amplification depending on their arrangement. Even if this were not so, we also often forget that such entities are complex systems themselves, which can only work thanks to the meticulous arrangement of their parts.

In an absolute sense, there are only four properties which can be considered fully aggregative, which are the ones subject to conservation laws in physics: mass, energy, momentum and net charge. In any other case we will have at most partial aggregativity, where only some of the conditions will apply. This allows for the analysis of different decompositions, utilizing the above conditions as heuristics in order to find invariances. Through this process we can identify regularities and approach model and theory building in a more accessible way, because we are able to diminish the dependence on the context, and by consequence the complexity of our descriptions. The identification of aggregative and non-aggregative properties then is not only an ontological question, but also allows us to construct some useful heuristics. First, emergence as a failure of aggregativity is, based on this analysis, the norm in our world. While this might seem an extremely weak definition, Wimsatt argues for its utility because of its classificatory and explanatory power. Reductionism and emergence in this way are fundamental for each other: we will be applying reductive heuristics at the beginning of our research, and as we come to understand more we can substitute our models with less idealized (aggregative) ones, which will make their emergent quality shine brighter. This characterization of reductionism is in line with what we saw above: we are employing it as a conceptual tool, not rendering it our goal. Wimsatt strongly criticizes statements which see the complex phenomena present in our world as “nothing-but” their underlying bases, like saying that our mind is nothing but neural activity. He identifies as a reason for such claims a functional localization fallacy, that is to say a consideration of only a particular decomposition, which will seem particularly aggregative, and a construction of inferences which deny any other possible configurations.

Multiple Realizability and Dynamical Autonomy as a Defining Characteristic of Levels

The last concepts we need to introduce before drawing our conclusions is Wimsatt's characterization of multiple-realizability of higher level properties, and their dynamical autonomy. He shares the view that multiple-realizability is a general fact of nature, stemming by two joint considerations: first, as we noted earlier, the fact that higher-level entities possess far fewer distinguishable states compared to their base counterparts; second that this multiplicity of micro-states must map into fewer macro-states, rendering multiple-realizability unavoidable. The recognition of this fact comes into play in his argument for asserting the causal dynamical autonomy of higher-level features. Another fact must be recognized before introducing it: higher-level features are more stable than lower-level ones, which undergo a constant flux of changes.

The consequences of asserting dynamical autonomy are, even if Wimsatt formulates it in a different manner, the reduction of Degrees Of Freedom. He notes that the vast majority of micro-level changes, which are happening in time scales so low that we might regard them as constant, do not have any significant causal influence on the higher-level entities, except in cases of chaotic dynamical systems. In almost all cases the existence of chaotic behavior in the physical base will not possess the causal potency to produce unpredictable behavior at other levels.

He provides an illuminating example taken from genetics in support of this thesis, a scientific area which is perhaps most notorious of showing how changes which seem insignificant can have vast consequences. In particular, he highlights the paradox of genetic variability and phenotypic stability. Given the extensive genetic diversity within species and the potential for minor genetic alterations to induce significant effects, one might predict a lack of phenotypic consistency among offspring and across generations. This expectation is contradicted by the observed heritability of traits and fitness levels, which occur with far greater predictability than chance. The preservation of phenotypic traits, critical for the evolutionary mechanism, necessitates a system where not every genetic change translates to a macro-level impact. Despite the potential for dramatic consequences from single gene or amino acid mutations, such as in sickle-cell anemia, the majority of genetic variations under normal conditions do not manifest in noticeable phenotypic changes. This phenomenon underscores a fundamental aspect of biological systems: their ability to maintain phenotypic consistency amidst genetic variability and change. This consistency is vital for ensuring reliable trait inheritance and adaptation to environmental changes, enabling evolutionary processes to unfold. The resilience of phenotypes to genetic variability suggests an underlying robustness in biological systems, allowing for evolution through selective pressures without being destabilized by every minor genetic fluctuation. The fact that even in such a sensitive domain the micro-level (genetic) variations can often lead to no consequences on the macro-level is a robust reason for asserting the validity of the above stated claims.

Furthermore, as we noted above, there will rarely be explanations at the micro-level which will be able to fully explain the reasons for the instantiation of stable macro-level properties, because of the radical diversity of the levels in which they are located. There are indeed times where lower-level explanations are possible and useful, but they will most likely be located at a level near the one of the property we are seeking an explanation for, not at the micro physical base. In other words, in the radical majority of cases, both from an explanatory and an ontological point of view, the reduction in Degrees Of Freedom not only implies, but also methodologically prescribes that most details are ignorable.

Our presentation of concepts related to emergence from different perspectives has come to an end. In the conclusion to this dissertation I will be drawing comparisons between the metaphysical approach of Wilson, and Wimsatt's focus on methodology. My goal is to show how these accounts find different points in which they coincide, allowing for their integration inside the philosophers conceptual toolkit, where both broader metaphysical considerations and grounding in actual scientific methodology could go hand in hand.

4

Conclusion

In this section we will be analyzing the affinities and divergences present in the aspects of emergence presented throughout this dissertation. First and foremost we will be showing that Wimsatt's positions align with the fundamental criteria for emergence, Cotemporal Material Dependence and Ontological and Causal Autonomy. Following that, we will attempt to integrate Wimsatt's positions into the tradition of Weak Emergence, even if we have identified some positions which seem to resemble more strongly the fundamental novelty of powers typical of Strong accounts of emergence. Comparisons will also be drawn between the presentation of non-aggregativity Wilson gives, compared with Wimsatt's account. Finally, we will be drawing correspondences between the Degrees of Freedom account, and the concepts of both Levins' sufficient parameter, which he adopts, and Wimsatt's dynamical autonomy.

You will remember that the definition of dependence we gave implies that emergent phenomena must be grounded on their underlying physical structure, which through its interaction gives rise to a higher-level phenomenon. This condition is implied throughout Wimsatt's work, given his focus on reductionism as a fundamental heuristic procedure, which of course in order to be executed necessitates some form of correspondence between levels. Furthermore, as we have seen, Wimsatt argues for a strong emphasis not only on the dependence of the lower-level components of the system, but also on the analysis of the context in which it is situated, a position that has recently been revisited in "Emergence in context: a treatise in twenty-first century natural philosophy (2022)" by Bishop, Silberstein and Pexton. Ontological and causal autonomy have also been asserted multiple times throughout our presentation. Not only have they been identified through robustness analysis for the entities that compose the various levels of organization, but also for the levels themselves. Through the definition of levels as local maxima of predictability and regularity we have seen how they are thought as autonomous parts embedded in the whole "phase space" that constitutes reality. Through robustness, which takes into account among other facts our possibilities of interaction with the different levels, the appropriateness of the theories that can be formulated by focusing on them, and the evolutionary interplay that happens between levels and their composing entities, we have identified various reasons for their autonomy, both ontologically and causally.

While it is now clear that Wimsatt's works are grounded in the principles of emergentism, the identification of his school of thought is less straightforward. I believe that the primary reason for this is his focus on pragmatic considerations, which by his own admission do not aim to offer all-encompassing definitions, but are instead adapted based on the specific question at hand. It's important to note that he does not imply that what has been presented so far possesses only a representational character, which constitutes the anti-realist position we presented through Heil's Picture Theory. We noted multiple times that once we have established robustness for the phenomenon or theory at hand we are asserting its autonomous reality.

In our presentation of Strong and Weak Emergence, we characterized their primary contrast as arguing for irreducibility vs. reducibility, and unpredictability vs. predictability. Wimsatt's positions on both topics are extremely nuanced, but I still believe that we can argue for a stronger alignment with Weak Emergence. My first reason for saying this is that, while he conducts an extensive and thorough criticism of any "in principle" position, he does this in light of his attention towards pragmatism. Consider the following phrase: "*In principle* results are results which are accessible to LaPlacean demons, but could nonetheless turn out to be unachievable for any present or conceivable future science."[45]. In this instance (but there are many other similar ones present throughout his works) he is not asserting that there is no possible way of describing or predicting a higher-level phenomenon from its physical basis. Instead, as we have extensively seen, he is arguing that there is no way *for us* to achieve such a result, a position which seems to me as fully in line with Weak Emergence. On the other hand, the jaws of termites example we presented earlier, seemed to assert a novelty present in the selection forces, which, coupled with the claim that their effects are not only recognizable at their level, but also in their DNA, gave us a characterization of downward causation which might also be in line with Strong Emergence. Still, as we noted there, through the recognition of the feedback loops present in the termites biological system, a weak emergentist can make sense of this position, and Wimsatt's discourse on the co-evolution of entities with their level could be taken as a testimony that he would agree with a weaker characterization. At the same time, it is important to underline that Wimsatt's considerations are still extremely valuable and should be taken seriously by any reductionist. It has become evident that arguing for eliminativist positions is counterproductive for any account which wishes to be useful to practicing scientists. The transformation operated by Wimsatt on the concept of reductionism into a heuristic tool has allowed us to identify instances where it should and shouldn't be applied, and has shown that sometimes it is sim-

45 Wimsatt (1994), p. 17

ply impossible for us to obtain a complete description of the phenomena in question. So, even if there are cases in which he argues for an impossibility of straightforwardly reducing phenomena, he does so in light of the fact that complex systems exhibit a contextual dependence that makes the task impossible, not in principle, but for us.

I believe Wimsatt’s analysis of non-aggregativity allows us to identify more closely this alignment. Going back to Wilson, she posited through Mitchell that the conditions present in non-aggregativity, including discussions around non-linearity and feedback loops, are not sufficient for underscoring the ontological and causal autonomy of the entities at hand. As noted previously, Wimsatt would agree that a reductionist approaching non-aggregativity can find several ways through which he can account for this kind of phenomena. Not only that, but reductions play in this context a fundamental role, among other things, in identifying the stability of compositional structures. This kind of analysis will highlight the contextual applicability of reductionistic explanations, as well as identify the biases associated with an eliminativist position. Thus, contra Wilson, Wimsatt argues that this position suffices for asserting ontological and causal autonomy. Thanks to the analysis conducted through the functional localization fallacy, which implies a focus on a specific configuration, while ignoring all possible others, Wimsatt arrives to the following conclusion: “If we focus too strongly on the preferred decompositions – which we will tend to do if those parts are the elements from which theoretical frameworks – they may come to seem to be everything, at least everything important. With only one such powerful position, descriptions will tend to be referred to or translated into its preferred entities. This may persist even when several powerful decompositions cross-cutting the system in different ways. Attending to such practices [Looking at other decompositions] changes our focus from how to specify relations between properties and the parts' properties (ontological questions) at the reasons for, process of, and idealizations used in decomposition, and broader effects of that choice (a set of logical and heuristic questions). […] Aggregativity provides tools for this kind of analysis in compositional systems – a demanding set of detectors for kinds of organizational interaction. Invariance claims are particularly sharp-edged tools for detecting, calibrating, and classifying failures of invariance. Yes, we are something more than quarks, atoms, molecules, genes, cells, neurons, and utility maximizers. And now we have some means to count the ways ”[46]. On this account, I would argue that it is not here that we should look for general ontological claims. His analysis was focused on locating reductive heuristics which are to be contextually applied, in order to arrive at more and more complex descriptions of phenomena, which in his account will be

46 Wimsatt (1997), p. 13

both emergent (and thus not reducible in an eliminativist sense), and at the same time explainable in a mechanistic way (one that probably won't ever be fully accessible to us).

Finally, let's conclude our analysis by drawing our attention to the resemblances between Wilson's DOF account, and the concepts of the sufficient parameter and dynamical autonomy. Levins, in the definition of the sufficient parameter says: "The sufficient parameter is a many-to-one transformation of lower-level phenomena. Therein lies its power and utility, but also a new source of imprecision. The many-to-one nature of "uncertainty" prevents us from going backwards. If either temporal variation or patchiness or low productivity leads to uncertainty, the consequences of uncertainty alone cannot tell us whether the environment is variable, or patchy, or unproductive. Therefore, we have lost information."[47]. The implication of a many-to-one transformation is of course a reduction in the DOF, which, for Levins as is for Wilson, implies that there is a substantial impediment in the application of reductionism to the lowest-level. This, in turn, entails ontological and causal autonomy. Wimsatt elaborates on the consequences of this approach. He notices that the correspondence of many lower-level descriptions correspond to a single upper-level description renders those upper-level states robust against variations among the lower-level states they encompass. This robustness grants upper-level phenomena a degree of stability and continuity, allowing for changes within macrostates or transitions to adjacent states without being affected by minor changes at the microlevel. Consequently, upper-level phenomena exhibit a form of explanatory and dynamic autonomy, insulated from and invariant over lower-level changes, reinforcing the idea of causal autonomy at higher levels of system description. Now, notice Wilson's reasons for asserting ontological and causal autonomy through the reduction of DOF: "[W]hat powers an entity has are plausibly a matter of what it can do; and the sciences are plausibly in the business of expressing what the entities they treat can do. It follows that, plausibly, what powers an entity has are expressed by the laws in the science treating it. The powers of E are thus those expressed by the laws in the theory treating (constrained) entity E, while the powers of [the system of ei] are those expressed by the laws in the more fundamental theory treating the (relatively unconstrained) lower-level constituents of [the system of ei]—that is, the constituents of [the system of ei] as existing both inside and outside the constraints associated with E. Consequently, the laws of the theory treating E express what happens when certain lower-level entities stand in relations associated with certain lower-level constraints, and the laws treating [the system of ei] express what happens when certain lower-level entities stand both in these relations and in other relations not associated with the constraints. Hence [the system

47 Levins (1966), p.429

of ei] has more powers than E, and the proper subset relation between powers in Weak emergence is thus in place."[48]. I believe that this passage allows us to assert that Wimsatt's ontological approach, while grounded in robustness, exhibits also characteristics which are extremely similar with DOF. Furthermore, the attention Wilson places on the recognition of causal powers of an entity at a given level through the fact that there is a theory accounting for them is definitely pragmatic in character.

This conceptual encounter between Wilson and Wimsatt shows the potential efficacy of a combined approach. Wilson conducts her analysis inside of metaphysical categories, while Wimsatt grounds his research on pragmatic methodology. Still, Degrees Of Freedom, a fundamental concept present in both of their theories, is arrived at through these different research methods. I believe this compatibility should serve as a basis for considering Wimsatt's approach seriously, and look towards a philosophy of science which is able to integrate successfully metaphysical considerations with Wimsatt's pragmatic approach, rooted in heuristics and robustness.

I want to conclude this dissertation by sharing a proposal taken from chapter 3 of "Re-engineering Philosophy For Limited Beings". Here, Wimsatt reflects on the general status of philosophy of science, and urges for a reevaluation of our philosophical perspectives, which he sees as rooted in the search for universal accounts of scientific practice, which in their journey to all-encompassing accounts might have steered away from what should be our real focus. On this basis, he proposes the following view: "I seek for philosophical methods the naturally rooted analogues to statistical mechanics; the "deeper" principles that yield and explain them in the limits, and explain when, how, and where fluctuations and deviations from those idealized pictures are possible and to be expected. From them, a naturalistic epistemology and a naturalistic methodology, extending to metaphysics and the valuational dimensions of human experience, should be both possible and inevitable. Naturalism need not be fundamentally eliminative or destructive of traditional views and methods. The essentials of philosophical methods can and must survive a thoroughgoing naturalism, but the naturalism includes societies, cultures, and ecosystems, with essentially all of our cognitive and cultural structures and regularities – descriptive, affective, and normative – intact as "phenomenological" laws and objects: reference groups, ideologies, and markets are as real as neurons, genes, and quarks. […] The tools we already have will look and act only a little differently than we thought – and mostly under unusual circumstances – but we will have a richer understanding of them. We will also have to learn how to use some powerful new tools, but for this minor inconvenience we get rich, deep, and robust connections with the world. […] I hope that this doesn't strain too many cur-

48 Wilson (2015b), p.387

rent conversations for architectural rendering for you to be able to see the inferential and presumptive modesty, and the power, coherence, and integrative promise of what I've got so far. A rain forest is a rich place after all, still far richer than we know".[49]

I hope that my presentation of these sometimes radically different perspective on the philosophy of emergence has helped in recognizing its future value. Emergentism is still undergoing constant development, and I believe that Wimsatt's contributions will be some of the fundamental tools we will need to employ in order to arrive to a true interdisciplinary account of these complex ideas.

49 Wimsatt (2007), pp. 34-36

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