ON THE IMPOSSIBILITY OF THE ONTIC VIEW OF MECHANISTIC EXPLANATIONS

A Master's Thesis

by
ALİCAN BAŞDEMİR

Department of Philosophy
İhsan Doğramacı Bilkent University
Ankara
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To my family

ON THE IMPOSSIBILITY OF THE ONTIC VIEW OF MECHANISTIC EXPLANATIONS

The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

ALİCAN BAŞDEMİR

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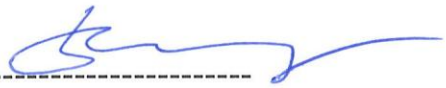

Asst. Prof. Dr. Yehezkel Sandy Berkovski (Bilkent University)
Supervisor

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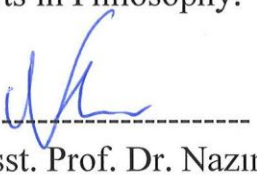

Asst. Prof. Dr. Nazım Keven (Bilkent University)
Examining Committee Member

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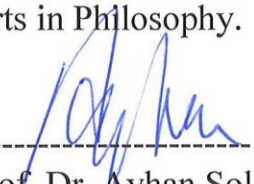

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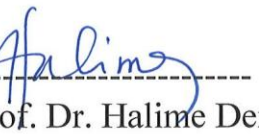
Approval of the Graduate School of Economics and Social Sciences



Prof. Dr. Halime Demirkan
Director

ABSTRACT

ON THE IMPOSSIBILITY OF THE ONTIC VIEW OF MECHANISTIC EXPLANATIONS

Başdemir, Alican
M.A., Department of Philosophy
Supervisor: Asst. Prof. Dr. Yehezkel Sandy Berkovski

May 2019

This thesis addresses the ongoing dispute among the New Mechanists on the epistemic and ontic conceptions of mechanistic explanations. The ontic view stipulates that explanations should be based on an identity relation that holds between mechanisms and explanations whereas the epistemic view suggests that explanations should go through a representational medium containing mental and external (scientific) representations to be qualified as explanations. I will articulate the presuppositions of the ontic view which will be followed by demonstrating ways in which the identity claim does not hold due to the distinctive features of actual mechanisms and their explanations. I argue that mechanisms are concrete structures which are based on actual causally productive activities whereas explanations are epistemically and pragmatically abstract items which cite relevant non-occurrences including absences and preventions. In addition, I challenge the weak onticism which is the idea that the ontic view can survive without the identity claim. It is based on

the ontic relation that connects explanations to the actual world while their relata are still explanations that is to say that explanations are representations which represent the ontic features of mechanisms. Lastly, I propose arguments to save realism about explanations to show how scientific practice of modelling is compatible with representational-subsumption view of explanations.

Keywords: Causal Explanations, Mechanistic Explanations, Ontic View of Scientific Explanations, Scientific Metaphysics, Scientific Modelling

ÖZET

MEKANİSTİK AÇIKLAMANIN ONTİK GÖRÜŞÜNÜN İMKANSIZLIĞI ÜZERİNE

Başdemir, Alican
Yüksek Lisans, Felsefe Bölümü
Tez Danışmanı: Dr. Öğr. Üyesi Yehezkel Sandy Berkovski

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Bu tez, Yeni Mekanistler arasında mekanistik açıklamaların ontik ve epistemik yorumlamalarına ilişkin devam eden tartışmayı ele almaktadır. Ontik görüş, mekanizmalar ve açıklamalar arasındaki bir özdeşlik ilişkisine dayanırken; epistemik görüşe göre, açıklamaların, açıklama olarak nitelendirilebilmesi için zihinsel ve dışsal (bilimsel) temsilleri içeren bir temsil vasıtasından geçmesi gerekir. Ontik görüşün varsayımlarını açıkça dile getireceğim. Ardından, gerçek mekanizmaların ve açıklamaların ayırt edici özellikleri sebebiyle özdeşlik iddiasının geçersiz olduğu halleri göstereceğim. Mekanizmaların, nedensel ve üretken etkinliklere dayanan somut yapılar olduğunu, açıklamaların ise yokluk ve önleme gibi olmayan ilişkili vakaları alıntılayan, epistemik ve pragmatik olarak soyut varlıklar olduğunu savunacağım. Dahası, özdeşlik iddiasından bağımsız olarak ontik görüşün hayatta kalabileceği fikrine dayanan zayıf ontisizme itiraz edeceğim. Bu, relataların (ilişkiye sahip olan) hala temsiller olduğu durumda, açıklamaları gerçek dünyaya bağlayan ontik ilişkilere dayanmaktadır. Bunun yerine, açıklamaların, mekanizmaların ontik özelliklerini temsil eden temsiller olduğu iddiasına dayanan, açıklamaların temsili-

kapsama görüşünü motive edeceğim. Son olarak, açıklamalar hakkında gerçekçiliği kurtaran argümanlar sunacak ve modellemenin bilimsel pratiğinin açıklamaların temsili-kapsama görüşü ile nasıl uyumlu olduğunu göstereceğim.

Anahtar kelimeler: Bilimsel Açıklamaların Ontik Görüşü, Bilimsel Metafizik, Bilimsel Modelleme, Mekanistik Açıklamalar, Nedensel Açıklamalar

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CHAPTER 1

INTRODUCTION

Wesley Salmon (1984a, 1984b) initiated a distinction between ontic and epistemic conceptions of explanations, namely, the ontic conception states that explanations are actual ontic ("causal-mechanical") parts and parcels of the real world whereas the epistemic view is dedicated to make phenomena intelligible through using psychological or other representational tools. The epistemic-ontic divide remains in the new mechanistic literature.[1] The dispute is ultimately tied to the fundamental assumption of the ontic view which I call "the identity claim" by which explanations are identified with mechanisms that exist "out there" in the world. The epistemic view replaces "the identity claim" with a "representational medium" in which explanations are mental and external (scientific) representations of mechanisms. The identity claim resists representationalism which assumes a stand-in relation between mechanisms and explanations. It also insists that descriptions of mechanisms cannot be ontic explanations since descriptions are linguistic representations of mechanisms which are heretic to the identity relation that the ontic view holds. This motivates us to conclude that the ontic view is neither representationalist nor descriptivist.

[1] The ontic camp urges to equate mechanisms ("ontic structures") with explanations (Craver, 2007a, 2014) whereas the epistemic camp is more liberal to recognize explanations as a combination of our mental and scientific representations which make phenomena more understandable and intelligible (Bechtel & Abrahamsen, 2005; Sheredos, 2016; Wright, 2012).

The current debate on the epistemic-ontic divide revolves around explanations instantiating ontic and epistemic norms.[2] The epistemic norms are (i) mentally grasping or representing phenomena, (ii) externally representing mechanisms with models, diagrams or data graphs, (iii) communicating mechanisms with others (Craver, 2014). The ontic constraints, however, are metaphysical dependence relations, namely, causal and constitutive relevance relations that characterize mechanisms. The idea is that proper mechanistic explanations should conform to both epistemic and ontic constraints. This encourages onticists and epistemicists to search for distinctive norms to show why their view is superior.[2] I will briefly articulate how epistemicists and onticists deal with norms that are imposed on explanations.

In the paper, I will first give a brief historical trajectory dating back to Salmon's works on different conceptions of scientific explanation in Section-1. Then, I will shortly introduce the basics of mechanistic explanations. Later, I will analyze the presuppositions of the ontic view that make it different from the epistemic view in Section-2. A part of it will be devoted to ontic constraints which onticists consider to be unique to the ontic view. However, I will claim that they are ubiquitously instantiated by both epistemic and ontic views. In Section-3, I will present two ways in which how the identity relation fails to hold between mechanisms and explanations. The first dichotomy is the inescapably abstract nature of explanations which distinguishes explanations from actual and concrete mechanisms that they explain. I believe that explanations are epistemically and

[2] This is called "the normative turn" developed by Illari (2013) who argues that mechanistic explanations conform to epistemic and ontic norms simultaneously. Craver (2014) also characterizes the divide as a normative divide doing justice to both epistemic and ontic norms but he keeps the ontic norm ("the identity relation") as fundamental. Sheredos (2016) claims that generality is the most distinctive epistemic constraint which make the epistemic view superior.

pragmatically abstract since some mechanistic details are omitted if they are unknown or irrelevant. The second dichotomy is the one between causal production and relevance, namely, mechanisms are characterized by actually occurring causal activities whereas their explanations have a broader ontology of activities which is inclusive of some relevant non-occurrences such as absences and preventions. Elaborating on these two cases, I will point out the unintelligibility of the identity claim. In the following section, I will challenge possible objections stating that the representationalist views cannot accommodate explanatory realism which is the claim that explanations cite the actual ontic elements in the world. Finally, I will argue that modelling-based science is canonical to mechanistic explanations which should encourage us to concede that some representations ("mechanistic models") are explanations. This will resolve the onticists' hostility towards model explanations since they believe that explanations cannot be subsumed under particular representations.

My ultimate aim is to show that the ontic stance on mechanistic explanations is not tenable due to the unintelligibility of the identity claim. The second reason is to reject the ontic view is that the interpretation of the notion of explanation offered by the ontic view does not get along with the actual scientific practice. Thus, the epistemic ("representational-subsumption") view is the only viable option for mechanists if it is characterized as representations that are directed to the worldly items in the world. The next task should be the search for constraints or norms on "adequate" mechanistic explanations without putting further effort to reveal the ultimate nature of explanations.

1.1. The brief historical trajectory

The received view in the literature of scientific explanation was *the covering law model* during the hey-day of logical positivism (Hempel & Oppenheim, 1948). It states that given particular antecedent conditions and laws (either universal or statistical), one can achieve explanations as inferences (Hempel, 1965). For instance, the value of temperature in a container can be explained based on the given particular quantities of pressure and volume and the ideal gas law. Also, one can explain (and predict) the blood group of a child based on the parents' blood groups and the basic Mendelian laws. Although this view is *prima facie* appealing to those who seek for subsuming explanations under logical statements, it fails to account for causation (Salmon, 1984a). There are certain ways in which the covering law model fails to incorporate relevant causes which are as follows (Craver, 2007b; Salmon, 1984a):

(i) *Irrelevancies:* Michael's taking contraceptive pills is not explanatorily relevant to the fact that Michael is not pregnant since biological males cannot be pregnant.

(ii) A*symmetry:* One cannot explain the height of a flagpole by having the height of its shadow and the specific angle of sunlight whereas the opposite scenario is plausible. The angle of the sunlight and the height of flagpole are temporally and causally prior to the height of the flagpole's shadow.

(iii) Common cause: The roster's crowing is not explanatorily relevant to the sunrise although the rosters usually crow during the early morning.

These objections motivate philosophers to dismiss the covering law model which is then replaced by more nuanced formulations of explanations. One alternative thesis is causal-mechanical theory of explanations stating that scientists explain

phenomenon by revealing its objective structure in the world (Salmon, 1984a). This account of causal explanations is dedicated to causal processes carrying and exchanging particular physical marks or conserved quantities (e.g., energy, momentum or molecules) that leads to causal interactions (Dowe, 1992; Salmon, 1984a; Salmon & Kitcher, 1989). This is a sharp departure from the Hempelian view since it replaces deductivism (or "inferentialism") with causal explanations. The logical positivist agenda of the Hempelian view does not explicity appeal to causation since it is a part of "speculative" discipline called *metaphysics*. Salmon's theory of causal-mechanical explanations is a metaphysical turn in the history of literature on scientific explanation.

The dispute between causal and the Hempelian theories of explanations motivated Salmon to make a distinction between two major conceptions of explanations (Salmon, 1984b). The Hempelian (or "inferential") view falls under *the epistemic view* which tries to represent phenomenon by adopting logico-deductive method without actually explaining the objective/causal structure of the world. The other one is *the ontic view* whose aim is to "exhibit ways how the phenomenon can fit into natural patterns or regularities" (Salmon, 1984b). The ontic theorists try to reveal the objective ("causal-mechanical") nature of phenomena by explaining them. To put it simply, explanations are 'out there' in the world. In other words, explanations are identical to phenomena-that-is-explained. This is what I call "the identity claim" later in the Section-3. Salmon adopts the ontic view to dismiss an epistemicism about explanations which he thinks to be inadequate to reveal ontic relations in the world. The dialectic between two mutually exclusive formulations of explanations still remains in the literature of scientific explanations.

1.2. Mechanistic explanations

Salmon's causal-mechanical theory of explanation is restricted to causal processes which does not capitalize on the mechanical part of explanations. The new mechanistic movement in philosophy makes a special focus on mechanisms which underlie or produce the natural phenomenon in the world. They mainly draw upon the literature on biology and mind-brain sciences since mechanisms are canonical to these sciences. The general definition of mechanisms might be summarized as hierarchically organized systems or structures which are composed of entities ("component parts"), activities ("component operations") (Bechtel & Abrahamsen, 2005; Glennan, 2017; Machamer, Darden & Craver, 2000). Here, entities (or "the component parts") are the building blocks of mechanisms which might be molecules, neurons, receptors, proteins or photons. Activities (or "the component operations") induce changes via entities (Machamer, Darden & Craver, 2000). The mechanistic entities can activate, inhibit, or produce a change relevant to mechanisms that they belong to. Mechanisms are also organizational. The ways entities and activities are composed determine the ways how mechanisms are organized. The mechanistic organization can be spatial, temporal and active (Craver, 2007a). Entities have certain spatial features such as orientation, conformation, direction or location which constitute the spatial organization of mechanisms (Craver & Darden, 2013). They also have temporal features since their activities might have particular durations, frequencies or periods. These spatial and temporal features impose entities to act in certain ways determining mechanistic organizations. Mechanistic explanations are supposed to track two metaphysical dependence relations that characterize mechanisms which are causal relevance relations

among entities and constitutive relevance relations (Craver, 2007b). One is etiological which refers to the antecedent ("relevant") causes bringing about mechanisms. The other is constitutive which refers to the internal elements that compose mechanisms. I will briefly sketch these two relevance relations that shed light on two aspects of mechanisms.

1.2.1. Causal relevance

Mechanists usually rely on manipulationist ("interventionist" or "difference-making") account of causation to make sense of activities (Craver, 2007a; Woodward, 2003). This is because it allows mechanists to track relatively stable activities among entities by intervening on particular entities. Biological activities such as activation, modulation, inhibition and repression are all results of the changes in the properties or causal powers of entities. By making difference to the properties of entities ("variables" in Woodwardian terms), one can see how activities come about or fail to occur. Woodward's interventionism is based on an ideal scenario called "ideal experimental conditions" can be summarized as following (Woodward, 2003: 98)[3]:

(i) An intervention I on the variable A makes difference to the other variable B. In other words, I changes the value or the probability distribution of A.

(ii) The causal path must be in the order of I-A-B. There should not be any intervention on A that is independent from I. There should not be any intervention including I that directly influences B. The intermediaries between A and B should not include any other interventions.

[3] The Woodwardian interventionism is not the only manipulationist approach of causation in the town but I will mainly rely on Woodward's account to avoid further complications related to different theories of interventionism (Kaestner, 2017; Strevens, 2008).

(iii) Interventionism has a counterfactual character which is intended to track "what-if-things-have-been-different" scenarios. Some counterfactual cases are considered to be genuine explanations within interventionist framework.

(iv) The causal activities should have stable or invariant generalizations meaning that they might be stable under changes in input, or intermediate parts.

An example might be the basic neural mechanism of nicotine. Nicotine binds to nicotinic acetylcholine receptors (AChR) which causes the opening of AChR receptors allowing sodium to get into the cells which induce further intracellular activities (Albuquerque, Pereira, Alkondon & Rogers, 2009). Here, nicotine, sodium and AChR are different entities or variables. Nicotine's binding to AChR is an intervention which causes the opening of AChR receptors. The prolonged exposure to nicotine upregulates genes coding for the AChR receptors which results in increase in the number of AChR receptors. AChR will need a ligand to function which leads a person to crave for nicotine (Albuquerque et al., 2009). This is sensitive to counterfactuals. If there was no exposure to high amounts of nicotine, AChRs would not have been upregulated. The example indicates that interventionism is a viable theory which is applicable to variables ("entities") constituting biological mechanisms. It, however, is not itself sufficient to account for mechanisms. There needs to be another criterion to identify which entities are relevant to mechanisms which is done by constitutive relevance relations.

1.2.2. Constitutive relevance

The constitutive aspect of mechanisms is based the constitutive relevance relations allowing us to demarcate which entities are relevant or irrelevant to mechanism-in-question. The idea is that the constituents of mechanisms underlie phenomena which suggests many levels that are mechanisms and the overall behavior called phenomena (Craver, 2007a: 121). These are not ontologically distinct levels but levels of mechanisms which are identified by top-down or bottom-up interventions. Suppose that phenomenon is spatial memory whose underlying mechanism is located in cells in CA regions of hippocampus (Craver, 2007a). The activities (binding, activating) of entities (calcium, AMPA receptors) bring about the phenomenon spatial memory whose functions are encoding, storing or retrieving navigational information. The criterion of constitutive relevance relations should take the inter-level nature of mechanisms into consideration.

The most common criterion for constitutive relevance is *mutual manipulability* stating that one can change the phenomenon by changing its parts or vice versa (Craver, 2007a, 2007b). Intervention is imposed on one level so that its effect can be detected on the other level. One can intervene on the parts (i.e., knockout, electro-physiological or optogenetic experiments) to detect the change in its phenomenon. She can also manipulate on the phenomenon (by top-down experiments such as neuroimaging or changing the time schedule of conditioning) to detect its effect on the activities or parts of mechanisms (Craver, 2007a: 145-146). Mutual manipulability is useful to distinguish between background conditions and relevant causes. Background conditions have actions-

at-a-distance such as temperature or pH that are causally influential but they are not significant for the mechanism since they are not constituents of mechanisms. Blood is required for the functioning of neurons since it carries materials required for neurons such as oxygen and glucose but it does not constitute mechanisms including spatial memory or neurotransmitter release. In absence of blood, these mechanisms will be malfunctioning but the manipulation by blood on phenomenon will not change the mechanistic constituents. Mutual manipulability *prima facie* seems successful to distinguish what is constitutively relevant and what it irrelevant to phenomena.[4] This adds another layer of mechanisms by which mechanisms are not confined to causes.

[4] Critics argue that mutual manipulability is not sufficient to reveal mechanistic constituents and the inter-level nature of phenomena. However, I skip these issues since they might exceed the scope of this paper.

CHAPTER 2

EPISTEMIC AND ONTIC ACCOUNTS OF MECHANISTIC EXPLANATIONS

Having presented a sketch of mechanisms, I will now examine the distinction between epistemic and ontic conceptions of mechanistic explanations and provide reasons why the ontic view is not tenable. The cut-and-thrust debate on the epistemic-ontic divide is mainly characterized by (i) *the epistemic camp* insisting on the claim that there are no explanations without (psychological, or scientific) representations and (ii) *the ontic camp* claiming that explanations are basically mechanisms themselves (Craver, 2007a; Bechtel & Abrahamsen, 2005).[5] I will defend the epistemic ("representational-subsumption") view of mechanisms since I believe that the bedrock of the ontic view, the identity claim, is unintelligible. I will articulate what I understand by the ontic view of explanations based on its implicit and explicit assumptions before assessing the identity claim in detail.

2.1. The presuppositions of the ontic view of mechanistic explanations

The ontic view of mechanistic explanations seems to hold some presuppositions which are as follows:

[5] There is an extensive discussion on the epistemic-ontic divide among mechanists who draw upon lexical ambiguity, generality or ontic constraints to defend their position (Illari, 2013; Glennan, 2017; Sheredos, 2016; van Eck, 2015; Wright, 2015).

(Identity) Explanations are identical to mechanisms. In its sloganic version, it is the idea that "Explanations are out there in the world". I believe that this is the most fundamental claim of the ontic view.

(Anti-representationalism) Ontic explanations are not representations.

(Non-descriptivism) Explanations are not texts or descriptions because they are just full-bodied things that exist in the world.[6] This is a special type of representationalism if one urges to hold that descriptions are linguistic representations.

(Ontic constraints) Explanations of mechanisms are subject to ontic constraints which is to say that explanations should instantiate particular causal and constitutive relevance relations.

Onticists might consider these assumptions to be "virtues" or "desiderata" of explanations since they believe that if explanations do not instantiate these virtues, they will fail to be explanations. I will touch upon each assumption which will be followed by the claim that onticists would be too quick to claim that their stance is the only right position among the available views which one might hold.

2.1.1. The identity claim

The identity claim presupposes the identity relation that holds between explanations and mechanisms. Hence, explanations, like mechanisms, are "out there" in the world. I suggest that this is the most distinctive feature of the ontic view. Mechanisms ("explanations") occupy a spatio-temporally characterized

[6] Here, I use descriptivism as the idea that explanations are descriptions - texts or sentential forms that refer to mechanisms and/or phenomena.

portion of the world. This is what makes explanations objective explanations. This is because, onticists think that the identity relation is what connects explanations to the real world. More evidence regarding the identity claim are as follows (Craver, 2014: 40):

> Ontic explanations are not texts; they are full-bodied things. They are not true or false. They are not more or less abstract. They are not more or less complete. They consist in all and only the relevant features of the mechanism in question. There is no question of ontic explanations being "right" or "wrong," or "good" or "bad." They just are.

As it is previously stated, the mechanists' inclination to the ontic view dates back to Salmon's writings. He confidently motivates onticism which he consider to be only way one can liberate explanations from any epistemic connotations.

> Explanations, in this [ontic] view, are fully objective and, where explanations of nonhuman facts are concerned, they exist whether or not anyone ever discovers or describes them. Explanations are not epistemically relativized, nor (outside of the realm of human psychology) do they have psychological components, nor do they have pragmatic dimensions. (Salmon & Kitcher, 1989: 133)

Ontic explanations are explanations *par excellence* which do not conform to any norms since they are mechanisms themselves. They are actual, concrete and complete things. They are parts of the world which exist without our knowledge of them. Onticists claim that the ontic view has two major advantages which are: (i) explanatory demarcation, and (ii) explanatory normativity (Craver, 2014). The former advantage is that the distinct status of explanations from other scientific achievements including description, prediction, control, or measurement (Craver,

2014). Explanatory normativity is the claim that the adequacy of explanations is ultimately based on ontic explanations. Many philosophers of science would agree on the idea that explanations should capture the ontic structures in order to be qualified as adequate explanations. However, not everyone would adopt the identity claim to buttress explanatory normativity. I will put a special emphasis on explanatory normativity in the sub-section that is related to ontic constraints of explanations.

Explanatory demarcation seems to be an intuitive thesis that explanation has some sort of a *sui generis* place among scientific achievements. Explanations are not merely controlling, measuring or predicting phenomena. Mere predictions depict the overall behavior of phenomena but explanations try to reveal the underlying mechanism. The prey-predator model can predict the overall distribution of the populations of prey and predators without "explaining" why it come out to be that way (Lotka, 1925). In addition, explanations might also be distinguished from control and measurement since they are not always data-driven by which certain variables are measured or controlled.

They are intended to reveal the ontic structures in the world. Ontic explanations have a special place if other scientific achievements are not directed to manifest the underlying mechanisms or the ontic structures. However, I am not sure that onticists make a clear demarcation between discovery and explanation. Scientists engage in some discovery or experimental strategies to reveal mechanisms which are channelled to "explain" mechanisms[7]. Some mechanists articulated strategies that are employed by scientists (Craver & Darden, 2013; Bechtel & Richardson, 1993). For instance, scientists engage in decomposition strategies by which

[7] Craver & Darden (2013) devoted to discovery strategies in biology to "carve up" mechanisms in which discovering and explaining mechanisms seem to be conflated.

mechanisms are separated into parts. When a neuroscientist remove a particular brain region by using lesion techniques, she can identify structural elements that brings about the phenomenon-of-interest. There are other discovery strategies such as localization, forward/backward chaining or modular assemblies which are cited in the mechanistic literature (Craver & Darden, 2013: 64-81). The use of the term "discovery" leads to an ambiguity in the literature since it is used interchangeably with the term "explain". This is an initial worry about explanatory demarcation but the confusion of two terms will not itself be sufficient to rule out the identity claim. I will articulate the criterion of explanatory demarcation to a greater extent in the chapter related to explanatory realism in which I claim that descriptions and explanations are not easily distinguishable from each other.

The other virtue of ontic explanations is normativity which is based on the ontic structures. The argument is that ontic explanation is what determines good and bad explanations. Explanations are directed to the wordly items – mechanisms with their entities, activities and organization. The content of explanations are mechanisms so that good explanations are good since they are able to explain mechanisms ("ontic explanations"). This is the gist of the explanatory normativity but it does not imply that explanations are only and solely subject to ontic norms. They should still conform to some epistemic norms which is linked to another view called "representationalism".

The identity claim seems to imply that we can solve all problems regarding demarcation and normativity if we equate explanations with mechanisms. I believe that this is a misleading assumption which quickly rules out any

epistemic view that can reasonably combine demarcation and normativity within an epistemic or representationalist framework.

2.1.2. Anti-representationalism

The identity relation rules out any duality between mechanisms and their explanations. Representations, broadly construed, are stand-in relations between a thing/phenomena/target ("represented") and its representation. As representations are often formulated as correspondence relations between two things, they do not satisfy any identity relation. Explanations in ontic sense cannot be subsumed under representations which exclude the identity relation. Explanations cannot be subsumed under deductive or linguistic representations which makes them different from the Hempelian explanations (Craver, 2014; Salmon, 1984a). They cannot be psychological or scientific representations. No representationalist account can suffice for providing ontic explanations. Although ontic explanations are ultimately non-representational, onticists do not disregard some epistemic norms that characterize explanations (Craver, 2014; Krickel, 2018). At least, contemporary mechanists go beyond Salmon's strict intuition that explanations have nothing to do with epistemic, psychological or pragmatic aspects of scientific practice. This means that the identity claim is not the end of the story for mechanistic onticists.

Epistemicists motivate representationalism about explanations by claiming that explanations can take two main representational forms which are (i) mental representations and (ii) scientific representations (Bechtel & Abrahamsen, 2005). Scientists should mentally represent or grasp the phenomenon to be able to explain it which is what Craver calls *epistemic-cognitive constraint* on

explanations (Craver, 2014). The other one is *epistemic-textual constraint* by which worldly structures are represented ("modelled") in certain forms such as diagrams, graphs or mathematical models (Craver, 2014). There is another constraint called *the pragmatic-communicative constraint* which requires explanations to be communicated with others (Craver, 2014). Some onticists seem to be well aware of the fact that scientific practice involves some epistemic norms. However, they still insist that explanations do not fundamentally depend on our epistemic access or mental representations. This retains the identity claim when explanations are understood to be worldly items. Epistemicists, conversely, would argue that there will be no explanations without our mental and scientific representations. Thus, representations have a crucial role in the formulation of explanations.

The epistemic view is sometimes called "representational-subsumption" view which identifies explanations with mental and scientific representations.[8] These representations convey some information about the ontic structure of mechanisms which is enough to satisfy as explanations according to epistemicism. The job of explaining is attributed to the cognizers who mentally and scientifically represent and communicate the mechanisms-of-interest. Mechanisms should pass this representational medium to be qualified as explanations. Thus, there is no explanation without an explainer ("representer") although mechanisms exist "out there" in the world without any need for someone who explain them (Bechtel & Abrahamsen, 2005). One may try to incorporate the ontic view into this overall

[8] Bokulich (2018) claims that all explanations are representations whose view is called "eikonic" theory of explanation. I am sympathetic to eikonic view but I am specifically interested in the articulation of the representational nature of mechanistic explanations. The representational view is also attributed to "the west-coast idealist" camp of San Diego School consisting of Bechtel, Wright, Sheredos, Churchland and Kitcher. My view is akin to these representationalist conceptions of explanations although I may not subscribe to Bokulich's fictionalism.

representational structure by characterizing the identity relation between explanations and mechanisms in the form of homomorphism or isomorphism. Onticists, however, will avoid this way of characterizing the identity claim since it implies representationalism. The items included in the ontology of explanations represent or correspond to the items of the ontology of mechanisms. I believe that any similarity-based theory implies two different things which correspond to each other but the identity claim will eschew all representationalist connotations. Thus, representationalism cannot be an assumption for the ontic view while its fundamental assumption is the identity claim.

The ontic view instantiates another assumption called "non-descriptivism" by which explanations are distinguished from texts or descriptions. This is tightly linked to representationalism if descriptions are regarded as linguistic representations of phenomena. I will now turn the debate about the distinction between descriptions and explanations.

2.1.3. Non-descriptivism

Explanatory demarcation makes a distinction between descriptions and explanations. It seems that the distinction goes back to the distinction between knowledge-that and knowledge-why. The "knowledge-that" gives us descriptions of phenomena whereas explanatory knowledge of events or phenomena gives us "knowledge-why" a particular event or phenomenon that obtains (Salmon & Kitcher, 1989). To describe is to access the appearances (they seem to be in the Humean sense) of phenomenon whereas explaining digs out the underlying causes or mechanisms.

An explanatory text can give us a description of a particular mechanism but it fails to give us an explanatory knowledge of that mechanism. This is clear from the ontic perspective. Since explanations are concrete, physical entities in the real world, they cannot be texts or descriptions. Descriptions are textual things which do not exist in the real world. Nevertheless, there are still some descriptions which have explanatory power. I will call such descriptions "explanatory descriptions" in an ontic sense but epistemicism does not imply any distinction between explanatory description and explanations.

Descriptions are associated with black or gray boxes which do not get into the hidden mechanisms that are responsible for the occurrence of phenomenon-in-question. By black or gray boxes, I refer to descriptions that gives some or no information about mechanisms-in-question (Craver & Darden, 2013). It seems as though explanations in its non-descriptivist form are transparent which fully open black or gray box nature of phenomenon. Explanatory descriptions, however, bear some information about mechanisms without providing glass boxes.

There are two types of explanatory descriptions in the mechanistic literature which are (i) mechanism sketches and (ii) mechanism schemas (Craver, 2007a). Mechanism sketches are partial descriptions of some mechanistic items whereas mechanism schemas are more complete descriptions of relevant entities, activities and organization. One can associate sketches with black boxes (including no mechanistic information) while relating schemas to gray boxes in which some mechanistic items are described (Craver & Darden, 2013). There are also ideally complete explanations- explanations par excellence which are concrete and complete explanations (Craver, 2007a). Psychological explanations are mechanism sketches which are partial explanations describing functional

elements (e.g., encoding, reconsolidation). These functional elements do not suffice for giving an information about actual mechanisms which are structures that give rise to these functions. Explanations in molecular neuroscience are mechanistic schemas describing the relevant items of a mechanism-in-question (Piccinini & Craver, 2011). They, however, are still abstract or partial since they do not fully capture the [ontic] nature of mechanisms. Explanatory descriptions are partial explanations that describe relevant mechanistic items but they fail to be ontic explanations due to their textual nature. As long as the identity claim is retained, explanations, ontically construed, cannot be regarded as descriptions. Explanatory descriptions are qualified as adequate explanations in the epistemic sense as long as they describe the relevant mechanistic items. However, it is still plausible to make a distinction between mere description and explanation. Explanations are not mere descriptions if they convey some information about the ontic structures without describing each and every detail that is considered to be relevant to mechanism-in-question. What are these relevant mechanistic items or the ontic structures that are conveyed or described by explanations? The answer rests upon ontic constraints which are aforementioned causal and constitutive relevance relations.

2.2. Ontic constraints

The ontic constraints are metaphysical dependence relations of mechanisms. I have previously articulated two metaphysical dependence relations of mechanistic explanations which are causal and constitutive relevance relations. Briefly, explanations should cite the relevant mechanistic items. By mechanistic items, I mean relevant causes and constituents of mechanism-in-question.

There might be a moderate interpretation of the ontic view claiming that the identity relation between mechanisms and explanation may sound unintelligible but proper explanations should ultimately contain the relevant mechanistic items by conforming to ontic constraints. They should cite the objective relation that holds between explanations and mechanisms (or facts and states of affairs) by referring to the metaphysical dependence relations.

This moderate reading of the ontic view will be receptive to the aforementioned epistemic constraints which are cognitive, textual and pragmatic-communicative constraints (Krickel, 2018). Explanations in practice require scientists to cognize, model and communicate mechanisms that are bounded with the ontic constraints of causal and constitutive relevance relations.

I believe that the moderate ontic view is not substantially different from the epistemic view of mechanistic explanations since epistemicism is also receptive to both epistemic and ontic constraints. The epistemic theorists may confidently claim that the relevant causes and constituents of mechanisms are described and represented (Sheredos, 2016; Wright & van Eck, 2018). The content of our representations ("explanations") includes some information about the relevant mechanistic items. It seems that mechanistic explanations are not mere representations which is to say that not all representations of phenomenon is mechanistic and explanatory if they do not contain relevant mechanistic items. In other words, explanations are directed at some portions of objective, causal and mechanistic worldly structures which rules out the claim that explanations are purely epistemic practices that has nothing to do with the actual world. Thus, ontic constraints are ubiquitously instantiated by both ontic and epistemic views.

This might motivate an alternative view which I call "the third way" approach to mechanistic explanations (Illari, 2013). The epistemic view states that explanations are subsumed under representations but this does not rule out the need to cite the objective structures in the world. The ontic view suggests that explanations conform to both ontic and epistemic constraints. Hence, there is no fundamental ontic or epistemic norms.

Explanations are not purely ontic since explanations require scientist to grasp, communicate and model mechanisms. They are not purely epistemic since explanations refer to ontic structures in the world. This encourages "the third way" approach which dismisses the epistemic-ontic divide. If epistemic and ontic norms are instantiated by both views, there is no actual difference between them. Normatively speaking, there is a neutral sense of explanation which picks out some ontic and epistemic elements simultaneously but none of them is fundamental.

I think that Illari's reconciliatory approach seems to rule out the identity claim which is the bedrock of the ontic view. Any ontic view that departs from the identity claim will fail to be qualified as the ontic conception of explanation. If explanations are not equated with mechanisms, mechanisms and their explanations will be different from each other. If the identity claim is dropped, there is no way to appeal to other norms of the ontic view including anti-representationalism and non-descriptivism. Illari's strategy seems quite consistent with the liberal reading of the epistemic view in which explanations are representations which carry some information about the worldly structures.[9] Thus, they conform to the ontic constraints since they are not mere

[9] Sheredos (2016) agrees with Illari's normative view but he adds a further epistemic norm which is generality that is not instantiated by the ontic view.

representations that are purely epistemic.[10] Illari's strategy does not make the epistemic-ontic divide non-sensical but it simply incorporates the ontic view into a broader epistemic account doing justice to both ontic and epistemic constraints without embracing the identity claim. I will now try to target the identity claim which I consider to be *sine qua non* of the ontic view.

[10] A fictionalist might appeal to the idea that explanations are mere representations which has nothing to do with the real world.

CHAPTER 3

MECHANISMS, EXPLANATORY ABSTRACTION, AND RELEVANT NON-OCCURRENCES

I will now challenge the identity claim by exposing two ways in which mechanisms can be distinguished from their explanations. This is intended to retain the duality that is drawn between explanations and mechanisms by the epistemic view. The identity thesis falls short of dissolving two dualities: (i) abstraction and concreteness, and (ii) causal relevance and production. I will defend the claim that causal production and concreteness are intrinsic to mechanisms whereas causal relevance and abstractness are features of explanations. By doing so, I will motivate the representational-subsumption view of explanations that prioritizes the intrinsic elements of explanations which are causal relevance and abstractness.

3.1. The dichotomy between abstraction vs concreteness

The first departure from the identity claim is the abstract character of explanations. Explanations as we are familiar with scientific practice always omit some features of the actual phenomena or mechanism due to some epistemic or pragmatic concerns. I will distinguish between epistemic abstraction and pragmatic abstraction. Epistemic abstraction is based on the fact that explanations are often relativized to the background knowledge of phenomena/mechanisms. Pragmatic abstraction, however, is a type of abstraction by which some features of actual mechanisms are deliberately

omitted.[11] Two types of abstractions make explanations more coarse-grained than their mechanisms which are fine-grained and concrete by their very nature. Thus, explanations will fail to be "full-bodied things" which are concrete items that populate a portion of the structure of the world.

Epistemic abstraction is instantiated by explanations in which some mechanistic items (causal and constitutive items of mechanisms) are omitted if these items are unknown or partially known by scientists. Until 2000s, molecular biologists were almost universally indifferent to the possible influence of some extra-genetic factors such as epigenetic modifications on the genetic makeup of organisms because they did not know that epigenetic factors can modify the activity of genes on chromosome (Krebs, Goldstein & Kilpatrick, 2011). Again, cancer biologists did not know that there are certain tumor suppressors such as tp53 which regulates the mechanism of cell growth (Krebs et al., 2011). Scientists posit explanations whose content is limited to the current knowledge of mechanisms. Although mechanisms as concrete things exist out there in the world, our explanations are not inclusive of each and every item that compose them.

Pragmatic abstraction is a deliberate kind of omission which is applied to explanations to abstract away from particular details that are considered to be irrelevant by scientists. Explanations in life sciences do not usually cite microphysical details or the cultural factors since they are recognized to be irrelevant to the particular phenomenon of interest. They have no "added value" for explanations since it is just redundant to cite too much details that are not directly related to the phenomenon. An explanation of DNA replication do not cite the certain composition of atoms that makes up what we call nucleic acids. To give a more solid

[11] It is often called "omission" in the literature of explanations and modelling.

example, molecular biologists usually work on some blotting methods by which expression levels of particular types of nucleic acids and proteins are analyzed. In most cases, they restrict the number of items that they want to investigate. For instance, one may investigate the effect of a particular drug on the role of UCP1 in transition from white adipose tissue to beige adipose tissue based on related proteins such as CGI-58 (Shun, Chanturiya, Shi, Gavrilova & Yu, 2017). They do not consider each and every protein that are included in the metabolism of adipose tissues which is not handy although they might be relevant to the mechanism of tissue-change. The actual mechanism of white-beige transition in adipose tissues, however, is concrete which is supposed to capture all relevant items in the mechanism.

Abstractions of either epistemic or pragmatic kind are permissible in mechanistic explanations as long as they include core mechanistic items. The core mechanistic items are entities, activities that are relevant to and constitutive of a mechanism. I further claim that abstractions have an ineliminable role in explanations. Mechanistic explanations ultimately instantiate some portion of mechanisms without revealing them with their full depth. That is not to say that explanatory abstraction has no degree of depth or breadth. Some explanations describe or represent more details compared to others. The degree of details that are included in explanations mostly depends on the scientists' practical interests (Craver & Darden, 2013). For instance, network models cite too many items that are represented by nodes that are connected to each other whereas graphical representations are specific to only particular items that are relevant to certain mechanism. Also, mechanism schemas describe more items compared to mechanism sketches. Psychological explanations are mechanism sketches which are confined to the functional aspects of mechanisms (Piccinini &

Craver, 2011). In the case of long-term memory, they explain how the cognizers encode, consolidate or store information whereas mechanism schemas gives details about the molecular and cellular mechanisms that underlie long-term memories (Craver, 2007a). Explanatory sketches are abstract relative to mechanism schemas. Both schemas and sketches, however, are abstract relative to the actual mechanisms since their contents are not inclusive of each and every mechanistic detail.

A preliminary objection against my characterization of explanatory abstraction might be the need to give a satisfying account of explanatory depth. Since the degree of abstraction should not be parasitic upon explanations, explanatory abstraction should provide a sufficient degree of explanatory depth by retaining core mechanistic items. The problem is that one may urge to drop the criterion of full depth ("concreteness") that is characteristic to the identity claim of the ontic view at the expense of giving an optimal degree of explanatory depth.

If abstractions (particularly pragmatic abstractions) are interest-relative, we can adjust how many details will be included in our explanations. Explanations should at least convey information about core mechanistic items. Here, I draw upon Strevens' idea that abstraction is permissible if they give us core causal claims (Strevens, 2008). If explanations abstract away from core causal claims, they will fail to be satisfying explanations since they will lose the relevant details. Mechanists will add constitutive items (entities that compose mechanism-in-question) to explanations including core causal items. Constitutive items or entities are identified by the criterion of mutual manipulability by bottom-up or top-down interventions.[12] Core causal items, in this sense, will be activities that belong to constitutive items.

[12] I set the problems regarding mutual manipulability aside. The worries about mutual manipulability revolve around two issues: (i) one can find out mechanistically relevant items that are not constitutive and (ii) constitutive items that are not relevant to mechanism-in-question.

Abstractions will retain the known core mechanistic items and subtract irrelevant details while failing to include relevant items that have not yet known. This, of course, does not suffice for positing a full-fledged account of explanatory abstraction. Nevertheless, it points out the fact that abstractions are essential features of explanations since scientists do not possess a capacity of omnipotence that would allow them to know all details about mechanisms.

The second objection might target the inclusion of core mechanistic items. If epistemic abstraction is an intrinsic feature of explanations, we may not know some of core mechanistic items. The extent of epistemic abstraction might be too large to omit some relevant core items. I previously argued that in mechanistic case, explanations are adequate if they cover core mechanistic items (causal or constitutive). If a core item is omitted, the mechanism-in-question will no longer be an adequate explanation. If the explanation of white-beige transition omits UCP1, it will be sketchy instead of being a mechanistic schemata. UCP1 is a core constituent of the mechanism-in-question. It would be argued that the degree of epistemic abstraction cast doubt on the distinction of explanatory sketches and schemas. If an explanation is a mechanism sketch by nature, the distinction is apparent since explanatory sketches abstract away from mechanically relevant details. Sometimes, it is not clear to find out whether an explanation falls under the category of sketches or schemas. In some cases, scientists hesitate to give an adequate explanation based on their discoveries or lack any knowledge of some core items. Again, this needs a full-fledged account of explanatory abstraction by which the adequacy of explanations is properly examined. However, the absence of such an account should not motivate us to claim that explanatory abstraction cannot be a feature of explanations since abstractions squares well with scientific practice.

The identity claim left us with huge explanatory depth in which all mechanistic items are preserved since the ontic construal of explanations imposes us to posit ideally complete and concrete explanations. It may seem intuitive to claim that abstraction is a global feature of explanations but onticists might insist on blurring the distinction between mechanisms and explanations. Hence, it is not clear how they can tackle the problem of abstractions which are parasitic upon the identity claim.

To summarize, mechanisms are concrete by their very nature whereas explanations are abstract. Abstractions stem from the fact that explanations do not cite (i) unknown or partially known details, and (ii) irrelevant details such as microphysical entities. There are degrees of abstraction which are based on some pragmatic concerns. Explanatory sketches are more abstract compared to explanatory schemas. Mechanistic explanations are universally abstract which do not instantiate mechanisms with their full complexity that has nothing to do with the fact that explanations' being sketchy or schematic. However, the identity claim might bring an absurd conclusion that mechanisms are concrete things, and by the same token, their explanations are concrete things.

3.2. The dichotomy between causal relevance and explanatory relevance

The second demarcation between actual mechanisms and explanation is associated with the criterion of causal relevance. There are two dominant views on causal relevance in the literature of mechanisms which are difference-making accounts of causation and process theories of causation (Craver, 2007a; Dowe, 1992; Salmon, 1984b). The process theory regards causes as actual occurrents or productive processes whereas the interventionist accounts are more liberal that identify any event/process/activity with causes as long as they are difference-makers. The

ontology of the process theory is limited to productive cases but the difference-making theories adopt a broader ontology of causes ("difference-makers") which includes cases of omission and preventions. I will briefly elaborate on both theories and examine their potential problems. Then, I will argue that mechanisms exhibit the actual causal relations since there are no negative events, processes or activities that actual mechanisms possess. Interventionist accounts, however, are useful to accommodate cases of possible causes (omissions and preventions) which are characteristic to biological explanations. My aim is not to defend a pluralist account of causation but to resolve the tension between two different theories of causation by claiming that mechanistic activities are productive and actual whereas some counterfactual or possible cases are relevant to their explanations. This motivates us to think that (i) mechanistic theories should be neutral to the dispute among process theorists and interventionists, (ii) the distinction between causal production and relevance supports the duality about mechanisms and explanations. The distinction between causal production and relevance will support the duality claim which is the bedrock of epistemic or representational-subsumption view of explanation since it implies that the selection of relevant causes and the insertion of relevant non-occurrences will be the prior task of explanations that are not confined to actual causes (productive causes) that characterize mechanisms.

3.2.1. Process theories of causal explanations

The process theory of causal explanations is defended by some philosophers that can be called "proto-neo-mechanists" due to their implicit emphasis on mechanisms. Salmon (1984b) called his theory "causal-mechanical theory" of explanation which highlighted the role of causal production but mechanisms within causal-mechanical

framework originally refer to physical mechanisms. The process theory stipulates that causal interactions occur when causal processes – processes that carry physical marks intersect with each other (Salmon, 1978). He later adopted the view that these physical marks are actually conserved quantities such as energy or momentum which are possessed by causal processes (Dowe, 1992). A conserved quantity is unchanged if it does not transferred. Physically speaking, it can be any quantity that is subject to the laws of conservation but it would be more general which is inclusive of any physical mark that stays constant such as molecules. Causal interaction occurs when processes possessing conserved quantities are exchanged. Suppose that there are two billiard balls A and B. A strikes B which causes B to move due to exchange of conserved quantities between A and B. Neurotransmitters are transmitted from one neuron to another due to exchange of some molecules including receptors, neurotransmitters and other proteins that are subject to physical laws. This theory seems to be applicable to many token or singular instances of physical causation which carry some conserved quantities. There, however, are three main objections that were raised against the process theories or production theories in general:

(i) Fundamentalism: The process theories are only applicable to physics which is the fundamental level (Craver, 2007a). No causation is possible at higher-levels.[13]

(ii) Relevance: The process theories cannot successfully distinguish between causally relevant and irrelevant scenarios.

(iii) Causally relevant non-occurrences: The process theories disregard non-occurrences such as omissions and preventions although they are intuitively relevant to explanations (Craver, 2007a; Krickel, 2018).

[13] This is called causal influence or biff in the literature of causal explanations.

The process theories often appeal to the cases in physics while theorizing about causation which makes them vulnerable to the objection of fundamentalism (Craver, 2007a; Glennan, 2011). The critics claim that conserved quantities only exist at the fundamental (physical) level. It is not clear that the causal relations at the higher-level phenomena such as biological or psychological phenomena can only be investigated by conserved quantities. It seems unintelligible to explain biological causes based solely on conserved quantities. Although biological processes are subject to laws of conservation or other physical laws, biological explanations do not usually cite physical laws or conserved quantities. The critics further argue that process theories of causation should be abandoned since there is no direct reference to conserved quantities in explanations of higher-level phenomena. Nevertheless, it seems that there is still a possibility for process theorists to rule out the fundamentalism objection by incorporating some biologically relevant entities such as molecules into the domain of conserved quantities. If molecules are conserved quantities, process theory is at least applicable to some sub-fields of biology including molecular biology, biochemistry, and physiology.

The second objection is about causal relevance which is actually a challenging case for all theories of causal explanations. One aspect of successful theories of causation is their ability to give a robust criterion of causal relevance. Suppose that one chalks the billiard stick whose remnants interacts with the billiard ball. Then, these remnants are transferred to the second ball while the first one strikes the second ball. Physically speaking, chalking the stick exchanges certain quantities at the lower level but the chalking is not causally relevant to the movement of second ball if it does not alter its trajectory. The process theorists might consider all productive process as causal although they are not relevant to the phenomenon-in-question. I will revisit

this problem later in this section. I believe that these cases are not irrelevant to physical processes but they are irrelevant to particular phenomenon-that-is-explained.

The last objection against process theorists is associated with their hesitation to appeal to counterfactual scenarios including some non-occurrent situations which are relevant to explanations (Craver, 2007a; Glennan, 2017; Krickel, 2018). The major candidates for such possible causes ("quasi-causes") are omissions and preventions (Dowe, 2001, 2011). Some non-occurrent events or processes are counterfactuals about genuinely occurring causal processes. The major ones are as follows:

Prevention: Suppose that X and Y are events, processes or facts. X prevents Y if X genuinely occurs and Y does not occur (Dowe, 2011). If X had not occurred, Y would occur.

Omission: The non-occurrence of X leads to the occurrence of Y if Y occurs and X does not occur. If X had not occurred, Y would not occur.

The cases of prevention are prevalent in biology. Biologists freely make use of words such as inhibiting, suppressing, inactivating, and blocking to refer to scenarios where there is a case of prevention. For instance, Parkinson's disease is characterized by the destruction of dopamine molecules in the brain region called substantia nigra (Carlson, 2014). A medical drug called *deprenyl* can be used to "inactivate" particular molecules including some types of MAO that causes the destruction of dopamine neurotransmitters in the brain (Carlson, 2014). In absence of deprenyl, there is a causal connection between MAO and the degradation of dopamine molecules. When deprenyl is given to the patient, the "blocking" of MAO will quasi-cause dopamine molecules to stay intact.

Omissions and absences are also common in biology. One of the major molecular reasons why depression occurs is the disruption of serotonin transmission (Carlson, 2014). In other words, serotonin molecules stay in one neuron which are not transmitted to other neurons. In absence of serotonin, some serotonergic (serotonin-induced cells) neurons cannot operate intracellular activities that occur upon the binding of serotonin to particular receptors in the cellular membrane. The absence of serotonin is an example of omission by which some intracellular activities (the reuptake of 5-HT) occur (Carlson, 2014). In presence of serotonin, the mechanism of the reuptake of 5-HT is blocked which is a case of prevention. In absence of serotonin, however, this mechanism is stimulated which is a case of omission. The process theorists might have a hard time to deal with these cases as they are inclined to consider all non-occurrences as non-causal.[14] This is a common criticism against the process theories by those mechanists who hold the interventionist accounts of causal explanations.

3.2.2. Interventionist (difference-making or manipulationist) account of causation

The problems of the process theory, namely, the problem of relevance, fundamentalism and causally relevant non-occurrences motivated some mechanists to embrace a more liberal account of causation which is the difference-making account of causation that is previously mentioned. The caricatured definition of difference making is that X is causally relevant to Y if X and Y are variables while X is temporally prior to Y. I call it a caricaturized definition since an intervention should comply with the norms of ideal intervention to be qualified as causal.[15] This

[14] Process theorists do not call themselves counterfactual skeptics but at least they avoid postulating a formal semantics that attributes truth-conditions to counterfactual statements (Dowe, personal communication).

[15] I briefly touched upon the criteria of ideal manipulation in the second section.

account of causation is counterfactually sensitive meaning that it is not restricted to actual scenarios. This allows us to compare cases in which there is actual cause or alternative (possible) cause (Woodward, 2003, 2011). This theory is based on causal models consisting of particular variables. We will come up with a different causal model when we intervene on variables that compose the model. Thus, interventionist theories are model-relative. Woodward's original aim is to give an account of causal explanation that squares with scientific practice. He does not urge to create a metaphysical account of causation revealing the nature of causation. This is compatible with the model-relativity of causes. I put an emphasis on model-relativity since it is parasitic upon ontic explanations. I will examine this problem later in this section. Although difference-making account promises us a better theory of causal explanation, they have their own problems. The problems of interventionism are as follows:

(I) *Selection*: The problem of selection is the difficulty in selecting causally relevant counterfactual scenarios while only a portion of possible cases are causally relevant.

(II) *Relevance*: The problem of distinguishing between background conditions and relevant causes.

(III) *Causal over-determination:* Interventionist theories cannot easily keep track of the actual causes of an event when there are multiple causes that potentially lead to the occurrence of that event (Krickel, 2018).

Interventionist theories seem to fix the problem of relevant non-occurrences by considering some omissions and preventions as relevant causes ("difference-makers"). They, however, face another problem, namely, the problem of selection. If a non-productive relation can be or in fact is regarded as a causal relation,

interventionist theories will have an exhaustive ontology of causes. In other words, if possible causes are genuinely relevant causes, there are infinitely many scenarios where we can identify possible causes. Interventionist makes sense of the distinction between relevant and irrelevant non-occurrent causes. They should tell us why MAO is causally relevant to the disruption of dopamine molecules whereas a falling rock is not relevant to the degradation of dopamine.

Craver makes a notorious claim about causally relevant possibilities by saying that the distinction between causally relevant and irrelevant cases rests upon our intuitions which is merely a psychological distinction (Craver, 2007a: 85). He suggests that "the distinction between intuitive and counterintuitive cases is a psychological distinction that is drawn on a number of different grounds in different epistemic contexts" (Craver, 2007a: 85). It seems that causal relevance of mechanisms is grounded on our psychology which satisfies the cognitive constraint that requires scientists to cognitively represent the mechanistic phenomenon. This relates back to the issues with model-sensitivity. It seems that difference-makers are relative to causal models which makes them -at least partially- mind-dependent. Interventionist do not always start with what already exists. Instead, they have causal models by which they investigate ways how certain variables might fit well with these models.

The second problem for interventionism is the criterion of causal relevance. Mechanists are usually interested in causal activities that are specific to locally-existing mechanisms. Hence, they exclude some events or processes which are causally efficacious but they are not really relevant to the phenomenon-of-interest. Some distal causes such as background conditions are removed from the ontology of

relevant causes. For example, the behavior of celestial bodies or blood are not relevant causes of the mechanism of cell cycle.

The solution to the problem of relevance rests upon the criterion of mutual manipulatibility. Mutual manipulability is a non-causal criterion that parses out what causally relevant activities and causally irrelevant ones are (Craver, 2007a, 2007b; Kästner, 2017).[16] It can dig out the activities among constitutive entities of mechanisms which are activities that are only produced by the mechanistic entities. On the other hand, there are activities which are produced by entities or objects which are not parts of mechanisms. The distinction, as mechanists suggest, rests on pragmatic considerations (Craver, 2007a: 157-158). Scientists do not consider background conditions as explanatorily relevant to the phenomenon-that-is-explained since it is not handy to use all details to explain the natural phenomena (Strevens, 2008). The oxygen levels in the blood is causally relevant to the mechanism of neurotransmitter release of the GABAergic neurons in the brain but they are not constitutively relevant to the mechanism-in-question. The presence of glucose is not considered while studying the activity of dopaminergic neuroscience just because scientists do not want to consider its relevance to the mechanism-in-question. I think that constitutive relevance is more fundamental than causal relevance for mechanisms since causal relevance usually make sense if it is considered within the boundaries of mechanistic constitution. This might motivate us to assimilate causal relevance to constitutive relevance in which there are some causal or non-causal dependence relations if all and only activities among constituents are of primary importance for mechanisms.

[16] There are causal interpretations of mutual manipulatibility (Krickel, 2018). However, I will stipulate it as the non-causal criterion to avoid discussing further problems.

There are still some cases that the difference-making ontology fails to incorporate. The interventionist strategy is originally designed to cover direct acyclic relations which are not cohere with cyclic activities. There are many types of cyclic activities such as positive or negative feedback loops in genetics, biochemistry and physiology in which the produced effect influences its cause. This is a heretic case for temporal asymmetry. The citric acid cycle is an example in which the citrate is both the initial difference-maker and the causal product of the mechanism (Berg, Tymoczko & Stryer, 2012). Glycolysis is another example in which the formation of the lactate- the causal product from pyruvate produces NAD^+ which then contributes to the production of 1-3-BPG which is an intermediary in the mechanism of glycolysis (Berg et al., 2012). These bi-directional causal relations confuses the original acyclic picture of the difference-making account since variable can make difference to their own difference-makers too. The difference-making account should be improved to include such cases that are prevalent in biology.

The last, but not least, problem of interventionism is causal over-determination (Krickel, 2018). Since interventionism does not suggest metaphysically robust theory of causal explanation, they cannot propose novel solutions to some problems that are characteristic to the literature of causation. Suppose that X and Y are causally relevant to the occurrence of Z. Causal over-determination occurs when one of the relevant causes (either X or Y) should actually cause Z while the other one fails to cause. Assume that X causes Z while Y fails to do. A difference made on Y will not change the value of Z although Y is causally relevant to Z. This is potentially problematic for interventionism since an intervention on the relevant cause must lead to a difference in the temporally succeeding variable. It is easier for process theorists

to deal with relevant causes in cases of over-determination as the only thing matters is the actually occurring causes.

Articulating two mutually exclusive accounts of causal explanation, I will now resolve the conflict between two theories by claiming that (i) actual mechanisms have causal activities which are productive in nature, and (ii) mechanistic explanations include actually occurrent and non-occurrent activities as long as they are relevant to mechanism-in-question. Then, I will argue that identity claim fails to make this distinction which threatens the tenability of the ontic view.

3.3. The dichotomies support the duality between explanations and mechanisms

The ontic theory of mechanisms adopts the difference-making theory of causation (Craver, 2007a). Interventionists eschews the process theory due to its fundamentalist and actualist tendencies. This is because, mechanist interventionists try to make use of omissions and preventions which are alternative "causal" scenarios. In addition, their main subject-matter is life sciences and mind-brain sciences whose explanations rarely include conserved quantities. It is worth to make a distinction between causal production and causal relevance. Although actual mechanisms are subject to causal relations which are productive, mechanistic explanations or descriptions cite only relevant causes which include non-occurring events in some cases.

Causal relevance within interventionist framework is based on the ontology of difference-makers. It is a broad ontology consisting of productive causes and possible difference-makers since both of them are relevant causes according to interventionism.

The cases of omissions and preventions tell us that there are difference-makers which are not causally productive. The possible activities are not causes in strict sense of physical causation. However, they are still causally relevant in the broad sense of difference-making since the absences or preventions make difference to some further variable. The difference-making ontology of causes include non-productive events or activities including possible causes or counterfactuals. However, they are explanatorily relevant to mechanisms although they are not causally productive in strict empiricist sense.

Causal productivity (an ontology containing actual causes) is a part of the difference-makers but some possible causes such as absences and preventers are causally relevant to mechanisms according to the broad difference-making theory of causation. If some quasi-causes or possible causes (absences and preventions) are allowed, they need to state why only some "possible causes" are allowed but not others. If all counterfactuals or possible causes are allowed, they will end up with an ontology that include infinitely many possibilities. This is the aforementioned problem of selection that interventionists must deal with.

Craver does not give a proper metaphysical criterion of selection. Instead, he acts the role of epistemicists by arguing that what is causally relevant rests upon the scientists' intuitions. If a strictly metaphysical element of mechanisms like causal relevance hinges upon our psychology or epistemic context, it would be absurd to claim that mechanistic explanations are fundamentally ontic. This is because, the ontic theorist like Craver seems to prioritize epistemic or pragmatic concerns over the ontic ones if the demarcation between relevant and irrelevant difference-makers depends upon psychological or pragmatic grounds. It seems that quasi-causes are explanatorily relevant to mechanists but they are not actual causes of mechanisms.

This motivates the idea that explanatory relevance is epistemically and pragmatically settled which goes beyond the relevant items composing actual mechanisms.

This is problematic for the identity claim because explanations have items which are not contained by mechanisms in the actual world. To repeat the conclusion of the previous section, explanations abstract away from actual mechanisms by leaving out some irrelevant productive causes and adding relevant non-causal activist to their content. The actual mechanisms have only actual causes (namely, productive causes) but the explanations of mechanisms are inclusive of possible causes including omissions and preventions. Background conditions are causally relevant for the actual mechanisms whereas they are not relevant to the explanatory framework of mechanisms. Explanations abstract away from the real mechanisms for explanatory purposes which distinguish the mechanisms in the real world from their explanations. Otherwise, onticists need to state why quasi-causes (absences and preventions) are actual tokens of causation to make sense of the identity claim.

My intuition about the identity claim seem to become a common view among some mechanists (Glennan, 2017; Krickel, 2018). Although Krickel (2018) argues that the distinction between causal production and explanatorily relevant causes will threaten the tension between two different approaches of causal explanation, she insists on claiming that the ontic view still survives in the moderate form. The moderate ontic view is called ontic since its relation is still determined by the ontic relations in the world despite the fact that the relata of explanations are descriptions and representations (Krickel, 2018). Her nomenclature is based on the relation of explanations. As long as the relation is ontic, explanations will remain ontic. The strong ontic view holds the identity relation between mechanisms and explanations which will make both relata and relations ontic. In other words, not only the

explanatory relation but also its relata are physical items. The strong ontic view will rule out descriptions and representations since it assumes that there is no difference between relata and relations.[17] The weak account drops the identity claim to motivate the idea that explanations are representations whose contents are the worldly items. Krickel's characterization of the ontic view assumes that the epistemic view cannot involve any ontic element since the relation must be epistemic such as mental representations, knowledge or sentences. She claims that epistemic theorists commit to the strong version of epistemicism by positing epistemic relata and relations. It seems to incorporate the epistemic view into an anti-realist framework since no ontic element is allowed for epistemicists. She claims that ontic elements might be physical entities like interlocutors who utter sentences or convey some information to others (Krickel, 2018). In this case, relata is ontic but the relation is epistemic.

If no ontic relation is involved, epistemicism falls into the trap of anti-realism. That is to say that epistemicists do not aim at explaining mechanisms by referring to their ontic relations in the world. I believe that the major epistemicists including Bechtel, Wright or van Eck do not urge to formulate an account of explanation that invokes anti-realism. "Explanations are not after the truth" is not the slogan of epistemicism. I will touch upon explanatory realism in the next chapter but I should state that Krickel's taxonomy leaves no room for epistemicists to posit an account that is inclusive of ontic relations. It seems to me that her taxonomy is a matter of stipulation in favor of saving the ontic view which does not do justice to the some versions of epistemicism. Her stipulation of the ontic view is not different than what I call "the moderate epistemic view" indicating that explanations are epistemic if they are descriptions and representations. If an account of explanations starts to

[17] Craver (2007) and Salmon (1984) seem to appeal the strong ontic view.

instantiate the virtues of epistemicism including representationalism or descriptivism, it will go beyond the standard ontic view in which the identity claim is canonical. Although Craver (2014) slightly modifies his ontic view by allowing pragmatic, cognitive and epistemic norms, he still retains the identity claim. The textual evidence is as follows, "the theory should distinguish explanation from other forms of scientific achievement. Explanation is one among many kinds of scientific success; others include control, description, measurement, prediction, and taxonomy." (Craver, 2014). He further reiterate what I call "the identity claim" (Craver, 2014):

> Ontic explanations are not texts; they are full-bodied things. They are not true or false. They are not more or less abstract. They are not more or less complete. They consist in all and only the relevant features of the mechanism in question (Craver, 2014).

The ontic view is clearly distinguished from descriptions, texts, representations which are abstract and 'more or less' complete. The identity claim is still alive for the ontic view since it provides a case for onticists to avoid descriptivism and representationalism. This supports my earlier argument that there is no ontic view left if there is no identity claim. In order to disambiguate the moderate versions of ontic and epistemic view, I prefer to call all of them "representational-subsumption view" of mechanistic explanations which is to say that explanations are representations of the real-world mechanistic items. I will now turn into ways in which the representational-subsumption account of explanations can be connected to the ontic structures in the world

CHAPTER 4

EXPLANATORY REALISM, EXPLANATORY DEMARCATION, AND THE ONTIC-EPISTEMIC DIVIDE

Explanatory realism, broadly construed, is the thesis that explanations or the content of explanations are real and correct since explanations are directed to wordly items. In this section, I will provide some claims about explanatory realism that has implications for ontic and epistemic conceptions of mechanistic explanations.

The first and the foremost assumption of explanatory realism is the existence of mind-independent reality. This is a metaphysical assumption that mind-independent reality exists. This can be aligned with an epistemic thesis that we have an epistemic access to mind-independent reality or a particular portion of mind-independent reality. The extension of this assumption for mechanists is that at least some portion of the world is populated by "mechanisms" so that mechanisms are real parts of the world. I will call it *realism about mechanisms* which is possibly the most dominant view that is shared by many mechanists regardless of their ontic or epistemic tendencies. We have access to mechanisms in the world so that we can discover or explain them.

The explanatory realism requires explanations to convey true information about worldly items that include their metaphysical dependence relations. Mechanistic explanations should contain true information about mechanisms and their relevant mechanistic dependence relations including causal and constitutive relevance relations.

The explanatory realism has two conditions: (i) substance independence, and (ii) status independence (Franklin-Hall, 2014). Substance independence is the claim that explanations are not functions of "concepts, capacities, knowledge or interests" whereas status independence is the idea that the adequacy of explanations should not depend on "concepts, capacities, knowledge or interests (Franklin-Hall, 2014). In other words, explanations should not be concepts which targets the claim that descriptions or linguistic representations can be explanations.

Craver's criterion of explanatory demarcation seems to satisfy these two conditions since it requires explanations to depart from texts, representations or other scientific achievements such as prediction, description or control (Craver, 2014). This is to say explanations have a unique place among scientific achievements which cannot be reduced to any other scientific successes.

To reiterate the distinction between ontic and epistemic accounts of explanations, ontic explanations rely on the principle of explanatory demarcation. Epistemicists, however, do not really problematize any dependence on descriptions or representations. I will revisit two conditions of explanatory realism and their possible insights for the ontic and epistemic views.

Explanatory demarcation attributes explanations a special place among scientific achievements by distinguishing it from any other scientific successes such as description, prediction, control or representation (Craver, 2014). The motivation behind onticists is to regard explanations as virtues that go beyond any connotation with descriptions, predictions, control or any other scientific achievements.

Revisiting Franklin-Hall's independence conditions, explanatory demarcation seems to require explanations to be substance-independent and status independent. These two conditions are intermingled in the case of explanatory demarcation.

Substance independence is the condition by which correct explanations are prevented from being functions of "our concepts, capacities, knowledge or interests" (Franklin-Hall, 2014). If an explanation states difference-makers or any other relevant causes, it would be regarded as substance independent. If psychological representations or capacities are prior to explanations, then the condition of substance independence no longer applies. If one restricts explanations into linguistic concepts or predicates, they again will fail to satisfy substance-independence.

The status independence, on the other hand, is the status of being genuine or right that is not dependent on "our concepts, knowledge, capacities, or interests" (Franklin-Hall, 2014: 5). An anti-realist might consider correct explanations as dependent on particular aims (i.e., control or prediction) or psychological capacities. These are heretic to the condition of status independence.

The ontic and epistemic views of mechanistic explanations may well define themselves as scientific realists of some sort. I will investigate how they might satisfy the aforementioned conditions of explanatory realism which is the view that explanations "exhibit" the mind-independent reality. In the case of mechanists, explanations should "exhibit" mechanisms that exist in the world.

The disputed territory among epistemicists and onticists seems to be substance independence whereas the status independence applies to both cases. The basic difference between two camps is that one considers explanations to be real physical entities in the world whereas the other equates explanations as a combination of various kinds of representations including mental, scientific or linguistic representations. I call the second thesis "representationalism". There is a special sort of "representationalism" that might be called "descriptivism" which are linguistic representations. Onticists eschew any connotation with representationalism of any

sort so that they are anti-representationalist and non-descriptivist. Explanations as representations or descriptions may fail to satisfy the first condition – substance independence since they become functions of some linguistic item, scientific models or psychological capacities. Nevertheless, they can still satisfy the second criterion which is status independence since they still depend on the wordly items called "mechanisms" in the world. I will examine each thesis in accordance with the attitudes that might be potentially taken by ontic and epistemic theorists.

Substance independence treats explanations as unique substances that are not descriptions, predictions or control. Onticists insist on such a condition to promote their view of explanations as real entities. This is aligned with aforementioned assumptions of non-descriptivism and anti-representationalism.

Non-descriptivism states that mechanistic descriptions including mechanism schemas and sketches are not explanations in the ontic sense. I subsume descriptions under representations but they are different sorts of representations which are mainly linguistic kinds. The motivation behind non-descriptivism is that the identity claim which is the thesis that mechanisms are identical to their explanations. Craver seems to argue that descriptions are linguistic representations in which mechanisms are the represented target systems whereas explanations are representations of these target systems in linguistic format (Craver, 2014). Explanations should go beyond descriptions whose content is restricted to the representation of the information about mechanisms in linguistic format since explanations are themselves exist in the world as physical items.

Craver's non-descriptivism can be traced back to Salmon's radical ontic view which differentiates between descriptive and explanatory knowledge (Salmon, 1984b; Salmon & Kitcher, 1989). Salmon claims that descriptive knowledge is the

knowledge of observables that locates in the phenomenal reality of logical positivists whereas explanatory knowledge exceeds the boundaries of mere observables by appealing to causal mechanisms (Bradie, 1996; Salmon & Kitcher, 1989) The formulation of the distinction between explanatory and descriptive knowledge on the grounds of observables and causal "unobservables", however, is not sufficient. It seems to me that there is still a place for descriptions to include causal mechanisms or unobservable "Humean springs" in Salmon's sense. Adding information about causal processes and mechanisms will only extend the scope of scientific descriptions. Salmon might have urged to rule out descriptions as linguistic representations which are confined to the observable reality since explanations as descriptions or arguments was characteristic to Hempelian covering law model of scientific explanation. This is because he associates Hempelian explanations as parts of "phenomenalism" about reality which is limited to the observable portion of the world. However, there is no need for descriptions to be limited to unobservables. The other reason why Salmon might avoid any descriptivism is that his adoption of the ontic view which stipulates that explanations are parts of mind-independent reality (Salmon & Kitcher, 1989: 133). Salmon considers explanations to be fully objective which are not epistemically relativized or dependent on psychological capacities (Salmon & Kitcher, 1989). Craver endorses a similar view of ontic explanations as full-bodied things in the world but he still is receptive to other epistemic constraints including mental representations, models and pragmatic-communicative constraints. They are not dependent on texts or representations. Instead, I previously claimed that mechanistic descriptions can well be defined as explanations. This does not mean that mere descriptions are explanations. Descriptions should refer to mechanisms with their entities, activities and

organization be counted as explanatory. This would solve possible problems that might be parasitic upon ontic explanations. These are (i) the problem of functional individuation, (ii) the problem of locality.

The problem of functional individuation is that mechanisms have particular role-functions which are potentially better captured by descriptions. Function is the role that a mechanistic part or the whole mechanism plays within a system (Cummins, 1975). For example, the function of cellular receptors is to bind particular ligands or to initiate some intracellular activities. The problem is that multiple functions can be attributed to the same mechanism or a mechanistic part. The function of adenosine receptor is to bind adenosine molecule but it can also bind to caffeine molecule (Carlson, 2014). The same structural element such as mechanism or mechanistic part can be described differently with respect to the function that it has. The description of mechanisms can change in accordance with the functional attributions. Explanations may not include each and every function that a mechanism individuate but there can be different descriptions of the same mechanism having different functions. This is compatible with two formulations of abstraction (either pragmatic or epistemic) which I articulated before. The functional individuation is problematic for the ontic view since it is not the real constitution of some mechanisms having a single function. For example, RNA viruses do not have any DNA so that they cannot replicate DNA from already existing DNAs (Berg et al., 2012). Instead, they use an RNA-dependent mechanism to produce RNAs. The function of RNA in RNA viruses is to replicate RNA or translate proteins by using the host cells (Berg et al., 2012). The mechanistic entities called RNAs in RNA viruses have different roles in different systems so that there are different functional descriptions for RNAs in RNA viruses. One description might contain the role of RNA in replicating genomic RNAs

in the host cells whereas another might describe the role of RNA in translating proteins. The different role-functions that the RNAs of RNA viruses have result in different descriptions of RNAs within different systems or mechanisms. There are variations of the mechanisms based on their role-functions which can be handled by multiple descriptions instead of ontic explanations that try to cover each and every relevant details about RNAs in RNA viruses. The mechanistic descriptions are contextualized to the role-functions although they exist in nature as organized things having multiple role-functions. This is a possible worry against ontic explanations since our explanatory descriptions are confined to some of the mechanistically relevant items.

The second concern is that mechanisms have a relative locality in nature (Illari & Williamson, 2011). The parts-whole structure is not composed of global "whole" and its parts. The mechanistic parts are items of local hierarchical mechanisms. The problem of locality is that the need of explanations to cover this relative locality. In addition, there is a possibility for descriptions to better refine these local structures. Spatial memory is a mechanism which has a hierarchically nested structure (Craver, 2007a). The lower-level is cellular or molecular activities of place cells in hippocampus. These cells bring about the phenomenon called "spatial memory" which allow mammalians to recognize spatial or navigational information. Although the mechanism underlying spatial memory is restricted to these place cells, there are some possible mechanistic or external items that penetrates into the mechanisms at different levels. These potential cases are problematic for the relative locality of mechanisms since they act at many levels. This requires onticists to include all relevant items in their explanations whereas the descriptivist strategy of epistemictist

can restrict explanations into some core items that specifically characterize the mechanisms by excluding other details.

Onticists do not provide sufficient reasons to clearly depart explanations from descriptions. These two problems can motivate philosophers to choose descriptivism over the ontic view. Descriptions may well cover worldly-items which might be confined to certain items or role-functions based on scientist's preferences. This does not imply that explanations as descriptions treat mechanisms as representational tools to capture some phenomena in the world. They can still be directed to the mechanisms by citing their metaphysical dependence relations. As long as the identity between explanations and mechanism is ruled out, there is no need to differentiate between mechanistic descriptions and explanations. The adoption of descriptivism violates the criterion of substance independence but it does not necessitate the adoption of anti-realism. As long as they emphasize the inclusion of correct information about mechanisms, they might well be called explanatorily realistic. Thus, Franklin-Hall's characterization of explanatory realism or Craver's explanatory demarcation should still be refined better to capture explanations as descriptions.[18] This, however, does not imply that explanations are mere descriptions or linguistic representations. Descriptions must convey correct information about mechanisms. Descriptions are not the only forms of representations while there are other forms of representations such as models and mental representations. Explanations are basically constellations of different modes of representations that represent the target systems called "mechanisms". I will devote the following section to representationalism about explanations which threatens status independence.

[18] She does not commit to explanatory realism since she believes that it is not compatible with scientific practice which is mostly related to local phenomenon.

CHAPTER 5

SCIENTIFIC REPRESENTATIONS AND MECHANISTIC EXPLANATIONS

Mechanistic explanations, ontically conceived, are "out there" in the world. The identity claim implies that explanations cannot be subsumed under descriptions and representations. I will now motivate the representational-subsumption view of explanations by claiming that scientific representations that are often practiced in scientific modelling are central to explanations. We should not hesitate to accept the idea that explanations are representations which is compatible with scientific practice. Then, I will examine how abstractions and idealizations might be relevant the explanatory roles of models and their contribution to the debate on the epistemic-ontic divide.

Onticists seem to be aware of the potential threat of modelling to the ontic view so that they have tried to address it to secure their position. They characterized several forms of modelling which are defined in terms of their completeness (Craver, 2006). By completeness, they mean the extent of relevant mechanistic items which are represented by the models. They are as follows (Craver, 2006, 2014):

(i) Phenomenal models: These models can represent the overall behavior of the phenomenon by giving no information about its underlying mechanisms. Hodgkin-Huxley model is an example which describes the behavior of action potential in neurons based on the changes in voltage but it does not refer the actual structures that give rise to the phenomenon of action potential (Craver, 2006; Hodgkin & Huxley,

1952). It is a mathematically formulated model by which the action potential of neurons are measured without citing details about the underlying molecular or cellular mechanisms.

(ii) Predictive models: These models only predict the true outcome of a phenomenon-of-interest. They also fall short of giving mechanistic details (Craver, 2014). The Lotka-Volterra's prey-predator model truly predicts the potential outcome of the pattern of prey and predator populations in a given environment (Lotka, 1925; Volterra, 1926). They do not reveal the structures bringing about this outcome. Although explanatory models are often predictive, predictive models are merely predictive which do not give an information about mechanisms. There is a wide consensus among philosophers that the expectability of a phenomenon does not suffice for explaining it (Craver, 2006; Salmon, 1984a; Salmon & Kitcher, 1989). An explanatory model should cite the metaphysical relations such as causes and mechanisms in order to be qualified as adequate.

(iii) Mechanism sketches: The sketch-type models are mechanism sketches which describe or represent a phenomenon without citing the mechanistic details which are previously articulated. They might be conflated with phenomenal and predictive models since they largely omit the mechanistic details. They, however, are partially explanatory compared to non-mechanistic models which fail to be explanatory. This is to say that they give information which currently include black-boxes that remains to be opened. The aforementioned examples are psychological models which represent the functional details whose responsible mechanisms are not included.

(iv) Mechanism schemas: The schematic models represent the relevant items about mechanisms. They are considered to be mechanistic models whose explanatory status is higher.

Models are explanatory to the extent that they represent target mechanisms with their parts, activities and spatio-temporal organization (Craver, 2006). They should satisfy the 3M (model-to-mechanism mapping) criterion that depict how this might be achieved as following (Kaplan & Craver, 2011):

> (3M) In successful explanatory models in cognitive and systems neuroscience (a) the variables in the model correspond to components, activities, properties, and organizational features of the target mechanism that produces, maintains, or underlies the phenomenon, and (b) the (perhaps mathematical) dependencies posited among these variables in the model correspond to the (perhaps quantifiable) causal relations among the components of the target mechanism (Kaplan & Craver, 2011).

This has (i) a qualitative feature representing mechanistic items and their relevance relations, and (ii) a quantitative feature representing organizational and causal relations in quantitative terms. Diagrams are of a qualitative kind whereas mathematical models such as data graphs are quantitative. Both types of modelling is canonical to mechanical models. Diagrams do not depict quantitative data but they give information about spatial and temporal organization about mechanisms by using arrows, shapes or spatial interactions. Data graphs are less "pictorial" but they are successful in comparing how well mechanisms operates temporally or spatially by giving data-driven relationships. To give an example, fruit flies have a specialized system of odor-associated memory whose mechanisms are located in neural structures called mushroom bodies (Kim, Lee, Lim & Han, 2013). A diagram of octopaminergic cellular activities in mushroom bodies exhibit how entities (ligands, receptors, intracellular proteins) and their activities (binding, initiation, complex-formation, phosphorylation) and the sketches of spatial organization. It, however,

lacks many information such as the exact region of an odor binds to OA receptor (a canonical receptor whose role is to bind an odor stimuli), the temporal (duration, frequency) activities or spatial features of entities (Kim et al., 2013). The cellular mechanisms underlie phenomena related to how fruit flies encode information about appetitive or aversive odor stimuli. Kim's working model of appetitive olfactory learning does not depict why these cellular patterns are associated with certain types (aversion and preference) of behaviors (Kim et al., 2013). The researchers also use data graphs based on experiments which test the functional sites in OA receptors in detail by comparing certain mutated and wild-type receptors. The data graphs add further information about how mutations in functional sites of receptors influence the behavioral pattern of fruit flies (Kim et al., 2013). The quantitative analysis allows researchers to assess the relationship between behavioral patterns and the cellular mechanisms. Although it is not specified in Kim's work, it is also possible to analyze temporal activities such as certain period or frequencies occurring in cells via quantitative models.

Many scientists frequently use models including diagrams and data-graphs to communicate their findings with others. It may not be possible to have one type of scientific representation to cover all mechanistic items. Scientists often use many models consisting of diagrams, data-graphs or mathematical models to convey information about mechanistically relevant items as much as models. The use of multiple models satisfy the modeler's need to capture relevant information about a phenomenon of interest (Burnston, 2016; Weisberg, 2007). The use of multiple models assist us in integrating more information about the structure and function of mechanistic items. This is more apparent in models such as network models or models in systems biology having huge-domain that is applied to complex

phenomena. However, generality is not the sole virtue of models. Thus, models are always sketchy or schematic which do not "authentically" represent each and every relevant items of the target mechanism. It is enough for models to include relevant items (Craver & Kaplan, 2018). This leaves a place for onticists to incorporate abstractness into their picture.

An onticist might be confident to claim that there are no model explanations due to anti-representationalist nature of onticism. They would argue that models are just heuristic tools that scientists use to depict phenomena since explanations cannot be models or any type of representations. They are explanatory as long as they represent the relevant mechanistic items but they fail to be explanations due to their inescapably representational nature. This is a sterile view of scientific explanations which is not attuned to the scientific practice – particularly modelling-based science. The explanatory framework conceived by the epistemic view can freely be inclusive of scientific representations as far as they are direct to mechanisms. Models are basically allows scientists to communicate and "explain" the mechanism-in-question. I claim that the epistemic view seems to be better candidate for scientific practice since it deals with idealizations and abstractions in a better way.

I devoted a section to abstraction while arguing for the duality between mechanisms and explanations. Onticists concedes that abstractions are parts of scientific practice of modelling. They claim that explanatory models are inclusive of abstractions and idealizations if they convey relevant items (Craver & Kaplan, 2018). They do not need to be fully complete that contain all information about mechanisms. This deviates from the identity claim which is the reason why onticists hesitate to consider models as explanations. I will now address the issue regarding idealizations and abstractions with respect to models.

It is not clear how onticists deal with idealizations. Idealizations are distorted elements or falsehoods that are inserted into models (Potochnik, 2017) (Weisberg, 2007). Idealized models are not really representations of the target systems or phenomena since they intentionally misrepresent the phenomenon-in-question. Frictionless planes, perfectly rational agents, infinite populations are types of idealizations that are used in sciences. They are representations as if they actually represent the target. Scientists are mostly aware of the fact that idealizations are unreal but they are included in models due to several reasons that can be generality, simplicity, computational tractability or lack of data (Potochnik, 2017). Onticists do not really deal with idealizations. They even claim that it is a problem for reference which is not a problem of explanations (Craver, 2014):

> The question at the heart of the problem of idealization is this: What is required for a given representation to convey information about the ontic structure of the world? This is an important question, but it is a question about reference, not a question about explanation. We only invite confusion if we fail to keep these questions distinct. (Craver, 2014).

It seems to be an escapist answer to the question of idealizations. Idealizations are apparent misrepresentations of a mechanism-in-question but onticists reiterate the claim that explanations are physical items by arguing that they have nothing to do with idealizations. Reframing the problem of idealizations in terms of a semantic question does not save the ontic view.

It is worth emphasizing the fact that the frequent use of idealizations in science which does not mean that scientists play with fictional worlds. They are aware that idealizations are unreal but they want to *understand* the actual world by using the *positive representational role* of idealization which is representing the reality as if it

has unreal features that the phenomenon does not actually have (Potochnik, 2017). This still saves realism since the world that is explained or modelled is real but the models representing the target systems by using idealizations are not. Idealized or abstract models convey some information about mechanisms but they are not veridical representations of mechanisms-that-is-modelled. We can achieve more veridically-formed representations by de-idealizing false elements in models. Craver seems to concede that scientists make free use of idealizations and abstractions to represent mechanisms (Craver, 2013a; Craver & Kaplan, 2018). It might be useful to emphasize that target phenomenon or mechanisms that are not abstract or idealized which is compatible with the view that explanations explain mechanisms as worldly-things. The way we construe these target systems by models intentionally inserts certain falsehoods or omit some elements. If someone like Craver insist on "complete" and "concrete" ontic explanations, there will be a minute range of models (or no models) that are actually complete, concrete, mechanistic and thus explanatory. There can be a more liberal account of mechanistic explanation that is attuned more to scientific practice and model-based science. Mechanistic explanations and models can still capture relevant causes, and constitutive elements that compose and produce mechanisms despite its abstract, incomplete or somewhat "idealized" nature.

Scientists do represent natural phenomena by modelling. Models do include abstractions and idealizations which are ultimately incomplete. Modelling-based science is useful for scientists to capture mechanisms to some extent without trying

to explain them with their full complexity and detailed nature. Models may ultimately be partial, elliptical, and incomplete.[19]

Scientific representations are not explanations for the ontic view due to its anti-representationalism. Hence, no diagram, no data-graphs, no mathematical model, no simulation model and no network model are explanations. They have heuristic explanatory roles in understanding mechanisms as much as their representation convey information about the world. This does not do justice to the actual practice in sciences – particularly special sciences which explain things by frequently using graphs, diagrams or any other types of models. They might be more or less adequate or correct which is an issue of how truly they represent the worldly phenomena. In other words, we should admit that models are not only instrumentally explanatory but also explanations on their own.

[19] This might blur the distinction between how-possibly and how-actually explanations. It is possible to claim that how-actually explanations will not be tenable if they guarantee us to exhibit the phenomena transparently without any abstraction. This is my preliminary intuition about the distinction between how-possibly and how-actually explanations that might be offered by the ontic view.

CHAPTER 6

CONCLUSION

The debate over the epistemic and ontic conceptions of mechanistic explanations is ultimately a debate about the identity claim – a claim stating that explanations are identical to mechanisms. The epistemic view, on the other hand, is dualistic about the nature of mechanisms and mechanistic explanations since it treats them as different sorts of things. If mechanisms are explanations, then explanations cannot be abstract, representational, and descriptions. Conversely, if mechanisms are not explanations, explanations can instantiate representationalism, abstractness and descriptivism as long as they are directed toward the worldly ontic structures. I will briefly sketch out the basic commitments of both views as follows:

(i) Identity claim: Onticism embraces the identity claim while epistemicism retains a duality between explanations and mechanisms.

(ii) Representationalism: Onticism holds that explanations are not subsumed under representations whereas epistemicism regards explanations as things that are subsumed under mental and scientific representations.

(iii) Descriptivism: Ontic explanations are not texts or descriptions. Epistemicism, however, allows some descriptions to be explanations.

(iv) Abstractness: Ontic explanations are concrete mechanisms whereas epistemicism holds that explanations are epistemically and pragmatically abstract.

(v) Causal relevance: Onticists usually appeal to difference-making ontology of causes but mechanisms are based on causal production which is the gist of the actualist view.[20]

(vi) Model explanations: Onticists defends an instrumentalism about models which is the idea that models are heuristically useful to explanations. Epistemicists, however, admits that there are model explanations if they are mechanistic models.

I have raised concerns regarding the identity claim. I argued that explanations are pragmatically and epistemically abstract since they do not include all mechanistic or physical elements. Some details are not known or mechanistically irrelevant. Also, I tried to deal with the difference-making ontology of causes which are useful to capture some cases of possible causes (omissions and preventers) but there are no non-occurrences for actual mechanisms in the world. Absences and preventions are difference-makers that are explanatorily relevant but they are not causally productive. Thus, they cannot be causes in the actualist sense. This might motivate onticists further metaphysical work needed to modify the criterion of causal relevance and production to make sense of relevant non-occurrences without reducing them to scientists' intuitions. This is because onticism will collapse into a type of representationalism if relevant metaphysical elements are reduced to any pragmatic aspect of explanations.

Epistemicism is considered to be unsuccessful in capturing the ontic structures which is the gist of explanatory demarcation (Craver, 2014). It states that explanations should not be representational if they reveal the portion of the wordly structures. The claim that explanations cannot be representational in order to be realistic is too sterile

[20] Not all epistemicists may commit to this view but I defend an actualist view of causation which makes a distinction between causal production and causal relevance that is made for explanatory purposes.

which disregards mechanism sketches and schemas. I emphasized that explanatory representations are more useful in describing different functional attributions and the local nature of mechanisms.

The anti-representationalist sentiment of onticism fails to give an account of explanations that coheres with the actual scientific practice. The significant portion of scientific practice is dedicated to scientific models. Scientific models can well be explanations if they can correctly represent entities, activities and their spatial, temporal and active organization. Ontic account treats such models as heuristic devices which inform us about mechanisms but they fail to be explanations in the ontic sense. The epistemic view, however, is inclusive of model explanations which are representational entities involving abstractions. They usually fail to capture all mechanistic items which arises a need to combine many models to explain mechanisms. A constellation of diagrams and data-graph will give us a picture of the actual mechanisms.

Mechanistic explanations try to reveal the ontic structure of the world but they are not parts or parcels of the structure of the world. They are successful, adequate, or correct if they represent these ontic structures by giving true information about them which is the aim of the representational-subsumption view that I tried to characterize. The discussion on the epistemic-ontic divide should now be directed to a new route that sheds light on what makes good explanations good instead of revolving around the debate regarding the nature of scientific explanation.

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