Kristina Engelhard
Michael Quante *Editors*

Handbook of Potentiality

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ISBN 978-94-024-1285-7 ISBN 978-94-024-1287-1 (eBook)
https://doi.org/10.1007/978-94-024-1287-1

Library of Congress Control Number: 2017963989

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Printed on acid-free paper

This Springer imprint is published by the registered company Springer Science+Business Media B.V. part of Springer Nature
The registered company address is: Van Godewijckstraat 30, 3311 GX Dordrecht, The Netherlands

Acknowledgements

We would like to thank Anna May Blundell for her profound proofreading and translation work. Without her help, we would not have been able to complete this project.

Contents

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Introduction

Kristina Engelhard

"The world is full of threats and promises" (Goodman 1983, 40); not only do we want to know which threats and promises there presently are, but also which ones there will be—maybe to a certain degree of certainty—in the future. If something is dangerous, it is disposed to cause harm under certain conditions at the present moment. However, if something has the potential to be or to become dangerous, we often want to say that it is not dangerous at present, but will become dangerous in the future under certain conditions. Physicians say that a certain virus has a high human-pathogenic potential if it is a virus that normally affects animals only but a small mutation could turn it into a variant of the virus that may very easily affect humans.[1] Potentials may also be promising: a violin teacher might be convinced that her six year old pupil Helen has the potential to play the violin on a professional level and teaches her accordingly. Investors might be convinced that Commerce Inc. has the potential to be or become a global player on the market and invest accordingly. Potentials may also be ethically relevant. According to the so

[1]E.g. some new types of avian influenza viruses (HN-viruses) are suspected of maybe turning into very harmful variants of HN-viruses if they undergo mutations that allow them to propagate under lower body temperatures than they do at present. Birds have a body temperature of about 38–42 °C, while humans have around 37 °C, e.g. H10N8. If H10N8-viruses were to undergo a mutation that would allow them to propagate at 37 °C an infection from human to human would be possible and hence it would be possible that avian flue would cause a pandemic (Nunes-Alves 2014). However, sometimes physicians speak of a human pathogenic potential also, if certain bacteria or viruses are presently disposed to cause severe illness if they infect humans.

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K. Engelhard and M. Quante (eds.), *Handbook of Potentiality*,
https://doi.org/10.1007/978-94-024-1287-1_1

called ‘argument from potential’ human embryos and fetuses have the potential for being a person and hence are at present bearers of full or some lower moral status.[2] Potentials are at least practically relevant: we discriminate entities by their alleged potentials and invest all kinds of resources for dealing with potentials: we either promote the manifestation of a potential if we think of its manifestation as something positive, or we suppress it, if we evaluate the manifestation of a potential as something negative.

The term ‘potential’ and all its forms differ in meaning. Some uses are predicative and hence at least seem to ascribe a kind of property to an object. A potential then is a property that an object may instantiate that involves either the mere possibility of it acquiring some other property or the disposition to acquire other properties. Or it may mean some property conferring a potential to its bearer due to its identity. Some uses, most of all as adverbs or adjectives, as in ‘Hepatitis is a potentially fatal disease’, mean some form of modality: either an epistemic or a metaphysical possibility.[3] In this example we normally want to say that if somebody is infected with hepatitis it is possible that he will die of hepatitis, if certain conditions obtain. We can understand this case as referring to the disposition of the hepatitis virus to kill human organisms under certain conditions.

There also seem to be slight differences in use between modern languages even of common origin like English and German. Whereas in English it seems more common to take the adverbial e.g. ‘x has the potential to be dangerous’ in the modal sense, normally meaning that x is possibly dangerous at present; whereas in German there is the liability to use the word ‘Potenzial’ only in cases that indicate the ascription of a property that is responsible for acquiring another causally relevant property in the future. By ‘x hat das Potenzial, gefährlich zu sein’, a speaker of German usually wants to say that x has some property that is responsible for it to turn into something dangerous in the future or if it is placed in different conditions x will be dangerous. So, the use of ‘Potenzial’ seems to be more restrictive in German than ‘potential’ in English; although there might be examples of the contrary also. This might also be a source of different intuitions with respect to the concept of potentiality in philosophical debates.

However, it is not at all clear what potentials are metaphysically. What do we refer to when we attribute a potential to something? What is it that a bearer of a potential has in contrast to something that lacks the potential, e.g. the potential for being a professional violinist? What are potentials, what is potentiality? And what are the truth-makers of propositions containing some form of potentiality vocabulary? And which role do potentials play in the different fields of philosophy and in

[2]According to some philosophers the potential for personhood is relevant for ethical problems of stem-cell research, stem-cell therapy, abortion, prenatal diagnostics and euthanasia. However, this is controversial (cf. Stier, this volume).

[3]Questions of reduction, e.g. whether the phrase also refers to a property, e.g. whether the Hepatitis pathogen has the potential to cause the death of the infected organism, will not be discussed. This is relevant for accounts that try to reduce possibility to dispositions resp. potentials (Borghini and Williams 2008; Vetter 2015).

the sciences. These metaphysical questions are the main issues of this book. It is not concerned with issues of language and its use. The basic idea of this volume is to give an overview of the metaphysics of potentiality on the one hand in the history of philosophy and on the other hand in several fields of contemporary philosophy and in the sciences.

The terms 'potential' and 'potentiality' reach back to ancient philosophy; the most influential framing of these terms to the present has been given by Aristotle. In Aristotle the concept of '*dynamis*', as a complementary term to '*energeia*', plays a central role in his metaphysics. It was primarily introduced to explain phenomena of identity and change. The ancient Greek term '*dynamis*' allows at least for two different translations into modern languages like English and German—mirroring the options for understanding the truth-maker of propositions containing potentiality vocabulary today: there is a merely modal sense by which '*dynamis*' can be translated by possibility or probability. And there is a predicative sense by which '*dynamis*' means 'capacity', 'faculty', 'disposition' or 'power'. These two senses of '*dynamis*', the merely modal sense of possibility and the metaphysical sense of some property with modal force have already been attributed to the ancient term *dynamis* by Aristotle himself in book 5 of the *Metaphysics* (1019a f.).

Aristotle also forms the concept through examples: the acorn that has a potential to become an oak tree, wood which has the potential to become a casket, the potential of a human sperm to become an adult human being, or the potentiality of children to develop properties inherited by their parents. However, Aristotle does not distinguish in principle between potentials and other kinds of dispositional properties, common natural dispositions—as fragility, malleability, heatability, freezability—or cognitive capacities of animals and humans—perception or epistemic capacities—or ethical capacities—like the virtues as capacities to act in a certain way. He does not seem to draw a principled distinction between examples of potentials in the narrow sense and common dispositions as the articles in this volume exhibit.

Hence, a further problem that can be traced back to Aristotle concerns the connection between dispositions and potentials. While it is a common opinion that potentials are at least a subclass of dispositions, it remains an open issue whether potentials just are dispositions, i.e. they are simply identical with dispositions, or whether there are features of potentials that make them a decisive subclass of dispositions. The acorn that has a potential to become an oak tree, wood which has the potential to become a casket, the potential of a human sperm to become an adult human being can be taken to be potentials in the narrow sense, while potentials in the wide sense include common examples of dispositions, like elasticity, flammability etc. The articles in this volume take different stances toward this question. Some authors argue that potentials are synonymous with dispositions, others argue for the claim that potentials are grounded in powers, i.e. causally efficacious dispositional properties (Mumford/Anjum). Hüttemann/Kaiser think that there are features of potentials, in this case in biology, that reveal that there are characteristics of dispositions in general that are easily overlooked when only taking into account the common examples of dispositions like fragility, flammability, elasticity, mass or

charge. These features are connected with the complexity of the manifestation process of potentials. Biological dispositions, according to Hüttemann/Kaiser, manifest by a process that has several more or less clearly defined stages, every step of which involves various dispositions in turn and which has certain starting conditions and termination conditions. Each step is also dependent on very specific environmental conditions. The manifestation of a biological disposition or potential involves changes of the entity of the potential. Makin finds in Aristotle the idea that potentials are not reducible to the dispositions the complex manifestation process breaks up into; a potential is not only a term for the collection of dispositions that participate in the complex manifestation process, but that there has to be some power on top directing the manifestation process to its specific goal because each disposition is multi-track. Other authors also deal with one or several of these features as candidates for a discriminating criterion for potentials—McKitrick, Mumford/Anjum, Hofmann, Kistler, e.a. McKitrick takes potentials to be dispositions to acquire a new property or to become a member of a certain kind. Another idea is to take them as second-order dispositions, i.e. dispositions to acquire yet further dispositions or as iterated dispositions, e.g. Vetter. Kukkonen shows that Avicenna held a similar idea in differentiating between proximate and remote potentials, with remote potentials being potentials the manifestation of which affords several steps that have to be taken until the final goal can be reached. However, all authors conform in the diagnosis that it is not possible to make the distinction precise.

Today, the terms ‘potential’ and ‘potentiality’ are used in a wide variety of senses in different areas of discourse, in philosophy, the empirical sciences and in language of everyday life. These different senses of the term ‘potential’ in philosophy are reflected by the contributions of this book. One aim of this book is on the one hand to highlight the historical sources of this term and its interpretation within those strands in the history of philosophy that are relevant for the evolution of the concept of potentiality and potential. And on the other hand to show how the concept is framed in the different fields of contemporary metaphysics including the metaphysics of the sciences.

Since Aristotle has most influentially coined the term in ancient philosophy the first chapter of this volume comprises three articles on Aristotle’s thought on the concept of *dynamis* in different fields of his philosophy, first in metaphysics, second in his philosophy of physics and biology and third his theory of the soul and his ethics. In the second chapter the volume is concerned with the tradition of the concept in the Latin and Arabic tradition of Aristotelian thought. The third chapter of the book is dedicated to the views on the concept of potential and potentiality in early modern philosophy. Here the concept is interpreted and evaluated along contrary lines in the empiricist and rationalist movements of that period. The following parts concern the use of the term in contemporary metaphysics, in specific fields of philosophy as the philosophy of mind, and bioethics. The last chapter is about the concept of potentiality in the sciences, in physics, chemistry, and in biology.

In her article "Potentiality in Aristotle's metaphysics" **Anna Marmodoro** investigates Aristotle's use of the concept of '*dynamis*' and shows, that his views on *dynamis* and its complement *energeia* should be understood as a metaphysics of powers. More specifically she points out that it is similar to contemporary pure powers theories, i.e. powers need not have a causal or categorical base and she thinks that Aristotle held a dispositional monism, i.e. the view that at least all fundamental properties are dispositional or they are powers. She delineates Aristotle's theory according to which the manifestation of powers needs complementary powers as manifestation conditions and that his model of manifestation is similar to a mutual manifestation model according to which powers are not triggered to become manifest, such that the trigger is just an activator of the power, but does not itself participate in the manifestation itself; on the contrary the manifestation of powers comes about by contact such that the manifestation is an ensemble performance of all participating powers. She reconstructs Aristotle's views on powers in detail and shows that Aristotle's theory even makes a unique contribution to the contemporary landscape of theories of powers: it establishes a model of powers according to which a power is in a sense identical with its manifestation. Powers are monadic non-relational properties. The power is wholly present when it is manifesting. The manifestation of a power is not a transition from one fact containing property F say to some numerically different fact containing property G say. But it is the transition of the very same property from one status to another, from a non-actualised state to its actualised state.

In his physics and biology Aristotle makes use of his metaphysical framework of potentials for explaining natural phenomena. However, Aristotle's model of potentials has been criticised in early modern philosophy. In his article on "Potentiality in Aristotle's physics and biology" **Stephen Makin** argues that this critique is not eligible and analyses the structure of physical and biological potentials in detail. He differentiates between two models of the transition from an inactive, dormant potential to its exercise. One model is binary, it takes the exercise of a potential to be an all or nothing affair. This model seems appropriate for those potentials the manifestation of which needs ideal manifestation conditions to obtain. Once the ideal conditions obtain, the potential exercises. The second is scalar, it takes the transition to be gradable. Now, Makin argues that in most cases of biological or physical potentials exercising in Aristotle the second model seems more adequate. Though, particularly the model of scalar potentials is open for the objection that potentials are not explicative because making reference to them to explain some fact that x F's is nothing else than saying that x F's because x can F, because the identity of the potential is fixed with reference to its manifestation only. This objection is not pressing for binary potentials, as Makin argues, because their identity is also fixed by their ideal manifestation conditions the identity of which can be fixed independently of the potential. It is however particularly pressing for scalar potentials. In Aristotle this objection can be rebutted because the manifestation of a potential breaks down into a series of underlying processes that are adequately taken to fulfil the binary model of potentiality manifestation that is not subject to this objection. Nevertheless the manifestation of the process has to be

governed by the scalar potential, because it is necessary to direct the underlying partial processes to a specific outcome.

Frans de Haas shows in his article "Potentiality in Aristotle's theory of the soul and his ethics" that Aristotle's views on potentiality stem from distinctions that Plato made in his ethics. The potentials of the soul are bound up with the capacity to acquire knowledge that is in turn a potential. As de Haas shows, according to Aristotle's theory two series are bound up with potentials: a series from not yet having, but capable of acquiring to having acquired and a series from possessing but not using to using. He then explores the various potentials of the soul, how they are interrelated and how this relates to Aristotle's virtue ethics. Aristotle's theory of a hierarchy of living beings from primitive animals up to the human being is structured by the potentials that these beings have. The human being has cognitive potentials the activation of which enables it to know by learning. In Aristotle the process of learning is a natural process, because it is a final goal of the human being to become a being capable of knowing. Furthermore, the human being has potentials of character and intellect, the potential to acquire virtues, a disposition to act in a way that enables it to achieve a happy life. The acquisition and exercise of the virtues is the basis of Aristotle's ethics.

Taneli Kukkonen starts his investigation of the interpretation of the terms 'potential' and 'potentiality' in the Arabic Aristotelian tradition with the early Arabic thinkers of this movement who mainly took up the Aristotelian conception without reframing it in any way. But then Avicenna and Averroes made innovative contributions to the Aristotelian framework. Their views were concerned with reconciling the Aristotelian metaphysics of *dynamis* and *energeia* with Islamic theological doctrines, first of all the omnipotence of God; hence it is God who bestows his creatures with powers and capacities. Avicenna understands the potential to have a lesser degree of being than the exercising of it. Nevertheless, he emphasises that the potential is the condition on which processes of change take place. This condition is prime matter. He distinguishes between proximate and remote potentialities; the sperm has the remote potentiality to turn into a man because it has to pass the state of boyhood. A proximate potential can immediately manifest. Averroes on the other side was more concerned to defend orthodox Aristotelianism against those thinkers who wanted to develop it further. The concept of potential is most central in his struggle: Averroes understands Aristotle to think that the identity of substances is fixed by their potentials. Since the substances are dependent on their potentials and since the potentials are dependent on their actuality and since the full actuality is only with God—as Averroes takes it—all substances depend on God.

Stephan Schmidt shows on the basis of Aquinas, Scotus and Ockham that during the medieval period in western philosophy the Aristotelian concept of potentiality was transferred from natural substances to the rational potentialities of God. The concept of natural potentials lost explanatory power while the concept of the rational potentials of God where introduced to overtake its explicative function. As a result in the early modern period the concept of potentiality was dismissed by Descartes and others because potentials were supposed to be epistemically

inaccessible and explanatorily idle. The concept of potentiality was introduced to western philosophy through the Arabic thinkers who made Aristotelian thought initially accessible. In Aquinas potentials of natural substances explain natural possibility, contingency and teleology in nature. Following Aristotle Aquinas differentiates between natural and logical possibility. Potentials are only apt to explain the first while logical possibility concerns the compatibility of concepts. According to Schmidt Aquinas has a normative concept of contingency grounded in fallible powers, i.e. powers the manifestation of which can be interfered with even if the manifestations conditions obtain. Scotus and Ockham however explain natural phenomena with reference to the rational capacities of God alone. Scotus's theory of modality takes possibility to follow from logical consistency only.

In his article on potentiality in rationalism **Michael-Thomas Liske** shows which theorems led most rationalists, esp. Descartes and Spinoza, to dismiss the concept of potentiality. The main reason for these two thinkers is their view of the relation between time and substance. Descartes dismisses potentiality due to his atomism with respect to temporal existence. This atomism leads him to reject a temporally persisting substance and hence the view of a substance realising its dispositions or potentials while persisting in time. Spinoza's monism of substance leaves no room for potentials of individual substances besides the one omniferous substance. And since this one substance is pure actuality, potentials are merely a descriptive affair of phenomena. Liske then points out why and how Leibniz, contrary to Descartes and Spinoza, retained the concept of potentiality. However the specific determinism Leibniz in effect is committed to, according to Liske, is contrary to at least traditional features of potentiality, including the metaphysical possibility of non-realised potentials. On the contrary, a Leibnizian monad necessarily realises all its potentials, due to its identity and also all a substance's future states are enclosed within its present state; there is no substantial change within a monad, which is contrary to common concepts of potentials, as Liske points out.

In her inquiry of potentiality in the British empiricists **Katia Saporiti** differentiates the views of the central thinkers Locke, Berkley and Hume. Although the common view is that unmanifested potentials are not perceivable and though this excludes them from being possible objects of knowledge in an empiricist framework, Saporiti shows that Locke accepts dispositional properties. Due to the close relation between potentials and dispositions this is relevant for potentials in the same way. Because Locke thinks that although we have no direct access to substances we can be justified to infer the existence of substances and think of their perceivable qualities as powers. Locke even assumes that we have indirect perceptual access to the powers of substances by their manifestations. Berkley on the contrary dismisses the concept of power in nature as vacuous, but accepts it in the mental realm. Only spirits can be causally efficacious and hence can have powers. Going even further Hume does not accept dispositions or potentials in his ontology at all. Basically it is his views on causation that goes against the acceptance of potentials: Hume's analysis of the content of our perceptions reveals—according to him—that there is no objective trace of the causal production of anything. Since sensation and reflection are the only possible sources of knowledge we cannot

know anything about necessary connections; we have no knowledge about the causes of change in nature. The idea of necessity originates from reflection. Hence Hume thinks that the ascription of powers to objects in nature is not based on powers in objects but on the constant conjunction of similar objects in the past.

Hume's epistemic worries and probably also Kant's critique of traditional metaphysics pushed the concept of potentiality into the background of philosophical thinking during the late 18th and 19th century. It, however, reappeared in contemporary philosophy a few decades ago in the context of metaphysical debates about the nature of properties, about what the laws of nature are. The second part of the book is concerned with the role the concept of potentiality plays with respect to these debates.

In her contribution "Real Potential" **Jennifer McKitrick** takes a realist position of potentials: she defends the thesis that the basis of something's having a potential is that this thing has a dispositional property. Since McKitrick is also realist with respect to dispositional properties this means that if something has a potential it has a certain kind of property, it can instantiate its dispositional property without manifesting it, because it takes certain conditions for its dispositional properties to become manifest. McKitrick argues for the causal efficacy of potentials qua dispositional properties. The contrary position to realism of potentials is anti-realism of potentials according to which the attribution of a potential can be true only in virtue of some non-dispositional property or some other entity. If potentials are dispositions then reductive analyses of potentials fail as well as analyses of dispositions. Potentials are, according to McKitrick, dispositions to acquire a property or become a member of a kind. She also argues for the thesis that there are extrinsic potentials, i.e. there are cases of potentials with respect to which it depends on circumstances whether something has the potential or not; two intrinsically exactly alike duplicates can either have or lack a potential just because they are in different environments.

In their paper **Steven Mumford** and **Rani Lill Anjum** argue for the claim that powers explain or metaphysically ground potentiality. This account includes the thesis that some potentials can be scientifically investigated because they are epistemically accessible. It also shows that and how the ascription of potentials is constrained, such that not everything has a potential for everything; however, something has a potential only if there is a power for it. Mumford's and Anjum's emphasis is on how powers jointly bring about their manifestations. They argue for a mutual manifestation model of powers, contrary to a stimulus response model that includes the powers causing their manifestation. By way of contrast to C.B. Martin's mutual manifestation model, which is a mereological model of manifestation, i.e. the manifestation of a power comes about merely by the coming together of the required powers to some specific manifestation. This underscores the temporal extension of the manifestation process that is specific to potentials, the manifestation of a potential often takes some time, from the moment of beginning to its completion. They furthermore argue that Martin's mutual manifestation model has to be amended with respect to the way the coming together of the powers is modelled. Contrary to Martin they think that the interaction of powers is a non-linear composition.

Barbara Vetter explores how potentials are explicative of natural modality. She shows how a theory of modality can be grounded on potentials. The common opinion sees the direction of explanation reverse; potentials are to be explained by possibility. Her concept of potentiality is very broad such that it includes common dispositions and potentials in the more narrow sense. This makes it possible to erect a theory of possibility on the concept of potential. On this account p is possible, if and only if something has the potential for p to be the case. The rationale behind this is the view that we are more acquainted with the concrete potentials of things in nature than with abstract possibilities. Nevertheless the account is not supposed to be reductive, because potentials contain modal features. Vetter shows that her analysis covers all relevant cases of possibility, if one accepts iterated potentials, i.e. potentials to acquire yet further potentials; one of her examples is my potential for my great-granddaughter be a painter. She then argues that it is plausible to assume that there are potentials such as these.

Part fife of the book deals with the different functions the concept of potentiality can play in different fields of philosophy. While it has an explicative function in the philosophy of mind it is used as basis of arguments in bioethics. **Frank Hofmann** shows, that it is a common thesis in the philosophy of mind that the mind is nothing but potential, the so-called potentiality thesis. This is understood as the claim that the mind is entirely constituted by its faculties that bestow dispositions. Hofmann shows that although there might be features that preclude potentials from being dispositions it turns out that there is no principled difference. However, the potentiality thesis is afflicted with difficulties as Hofmann shows, although potentials play a very important role for understanding the mental. A central feature of the mental is its normativity. According to Hofmann this cannot be accounted for by dispositions. Also, context-externalism, the claim that in order to have certain kinds of intentional mental states it is necessary to be related to the external world in the right way, is incompatible with the potentiality thesis, because according to Hofmann the relation is an actual relation, not a potential. Finally, phenomenal consciousness cannot be accounted for with reference to potentials because it is manifest in a way that involves features that are not dispositional but actual.

Marco Stier discusses arguments in bioethics for which potentials play a central role. One argument takes potentials of human embryos to account for their special moral status. This argumentative use of the concept of potentials is made in arguments against abortion, embryo or stem cell research and artificial reproduction. The core premise of one version of this argument from potential runs thus: Because a human embryo has the potential to become a person in the future—or is a person with potentials—it now has the moral status of a person. Stier points out that there are two different issues that have to be taken apart. One issue is with the metaphysics of the relevant potentials and the other is with their normative relevance. He discusses the differing meanings of the concept of potentiality in bioethics and which consequences follow from them for the argument from potential. Stier discusses the numerous objections against the argument. His thesis is that since the concept of potentiality in the special case of potentials that are related with personhood has normative consequences, the concepts of ‘potential to become a person’ or ‘person

with a potential' are themselves normative concepts in bioethics. Potentials also play a role in debates about human persons in special situations, like brain-dead patients and about special beings like human-animal chimeras.

The articles in the sixth part of the book are devoted to different sciences for which the concept of potentiality is relevant. These articles reveal that the concept of potential or potentiality has different meanings and plays very different roles in physics, chemistry and biology.

Max Kistler shows that 'potential' is a technical term in physics whereas scientists do not use 'potentiality'. However the term 'potentiality' is also helpful in the metaphysics of physics. Classical physics includes the term 'gravitational potential' and the capacity of heat, which can be categorised as a potential. In quantum physics Heisenberg used the term in his interpretation of quantum mechanical systems in superposed states. Potentials in physics are states of systems; a system has a potential if all its forces are conservative; potentials in physics are scalar quantities. Some potentials in physics are convenient ways to represent fields and forces like the gravitational potential. There is however good reason to think that there are cases of potentials in which the potential is a real entity because it is causally efficacious. As Kistler points out potentials are dispositions of a certain kind—according to Kistler the demarcation between the terms 'disposition' and 'potential' is pragmatic; they are dispositions the manifestation of which takes more or less time than with common dispositions and they make their manifestation more or less probable but not necessary. Kistler however also registers differences between the use of disposition terms and potential terms: if a potential is manifested it is less appropriate to still attribute the potential. In his discussion of Heisenberg's interpretation of quantum mechanical systems in superposed states Kistler argues that quantum mechanical phenomena underscore a certain theory of the difference between categorical and dispositional properties, namely that they are two ways to refer to properties rather than two numerically distinct kinds of properties.

In chemistry potentiality is at stake in the very central problem of the identity of chemical elements over time, as **Robin Hendry** and **Paul Needham** show: how are we to account for the elements within a compound substance: are they actually or potentially present? While atomism affirms the first disjunct Aristotelians affirm the second. However, what does 'being potentially present' mean? Hendry and Needham examine whether and to which extent modern chemical theories are able to underscore the atomist model. Their thesis is that they only partially confute the Aristotelian model. The Aristotelian model, according to which the elements are potentially present within a compound substance, assumes that the elements are potentially present in the sense that they can be recovered by separation of the elements. Atomism on the other hand has to maintain that the separation of the elements is a rearrangement of parts of matter such that they persist throughout the changes that they undergo. However, modern chemistry shows that the transformation of substances do not underscore this view, the portions of matter before being transformed into the compound substance cannot be identified with those portions that result from the separation process. This casts interesting light on processes of change and the role of potentials within these processes.

In biology potentials form an important group of properties of biological systems that are a subtype of dispositions as **Andreas Hüttemann** and **Marie Kaiser** argue; there are biological potentials in molecular biology, cell biology, developmental biology, evolutionary biology, and ecology. According to Hüttemann and Kaiser biological dispositions share two features: first, their manifestation process is a complex process of consecutive stages and second, that the manifestation conditions are highly specific collections or series of several elements. Furthermore, Hüttemann and Kaiser show that the concept of potentiality is a useful tool to describe the explicatory practices of biologists. They also argue for the claim that a dispositional account of natural properties provides a conceptual framework that makes biology and physics comparable sciences. Explanations by cp-laws, as in physics, and mechanisms, as in biology, can both be regarded as referring to dispositions. They analyse examples of biological potentials in the different fields of biology and show which influence complexity has on the manifestation conditions and the manifestation process of potentials. It turns out that biological potentials involve not only trigger conditions and background conditions for their manifestation like common dispositions but also sustaining conditions, conditions that have to obtain at very specific stages of the manifestation process and that are causally relevant for the temporally extended process to continue. Hüttemann and Kaiser also underscore the thesis that there are extrinsic potentials in biology.

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Part I
The Concept of Potentiality in the History of Philosophy—Aristotle

Potentiality in Aristotle's Metaphysics

Anna Marmodoro

In this paper I will argue that Aristotle built his ontology *solely on powers*.[1] On my reading, Aristotelian powers are *pure* powers. That is, all there is to a power is its powerfulness; nothing inert, or impotent is needed in the power's nature to anchor the power to reality.[2] But from this—namely that all there is to a pure power is its powerfulness—it does not follow that all there is to a pure power is potentiality. This latter position, which one encounters in contemporary accounts of powers, has the unwelcome consequence that a world of pure powers only is a world of potentialities only. I will argue that in Aristotle's system pure powers are actualised, not by a transition to different potentialities, but by a transition to a different status of the powers themselves.

Ontologies of pure powers are invariably construed as relational ontologies—powers in potentiality are taken to be essentially related to further powers in potentiality, namely, to their manifestations (see e.g. Bird 2007). Aristotle's power ontology, by contrast, is *not relational*. On the one hand, a power in potentiality is the same power as its manifestation—so being manifested does not relate a power

The *European Research Council* and the *British Academy* have supported two different stages of the research leading to the preparation of this article.

[1]This interpretation makes a radical departure from the traditional ways Aristotle has been understood. I articulate it and defend it more fully than the limits of the present paper allows in Chap. 1 of in my monograph *Aristotle on Perceiving Objects* (2014).

[2]Contrast with views on which a power has a categorical basis (e.g. Ellis 2010), or is qualitative as well as powerful (e.g. Heil 2003).

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K. Engelhard and M. Quante (eds.), *Handbook of Potentiality*,
https://doi.org/10.1007/978-94-024-1287-1_2

to a further power in potentiality. On the other hand, although Aristotle's powers are dependent on other powers in order to be activated, they are not related to these other powers through polyadic relations, such as '*x* being the father of *y*'. For Aristotle ontological dependence is grounded on monadic properties, such as '*y* being a father' and '*x* being an offspring', that belong to interdependent entities. Thus, neither the manifestation of powers nor the interdependence among powers require introducing polyadic relations in Aristotle's ontology.

The ontological interdependence between powers structures them into a (non-relational) nexus, which is the bedrock of reality for Aristotle. Some of these powers are in potentiality and some in actuality. Powers in actuality are activated powers, exercising their powerfulness; they do not cease to be powerful while activated, nor is their powerfulness reducible to mere potentiality. Thus, powerfulness is either the potentiality to bring about change, or the actuality of bringing about change.

Thus Aristotle's ontology is a structure of interdependent powers at different stages of activation. Aristotle allows for three different ontological states of a subject in reference to a power: a subject *s* can possibly acquire a power (*s* can acquire the power of playing chess, or of heating other objects); *s* can have a power in first actuality (*s* has acquired the power to play chess and is not playing chess, or the power to heat other objects but is not heating any objects); and *s* can have a power in second actuality (*s* is playing chess, or is heating other objects). On my reading, for Aristotle both the first and the second actuality statuses are compatible with a power retaining its powerfulness, even if not in all cases its potentiality. This is why powers remain powerful while in actuality. This reading of Aristotle shows his account of powers to be importantly different from the contemporary accounts of powers, in that Aristotle does not identify the *powerfulness* of a power with its *potentiality* (or, in other words, to its *dispositionality*) [e.g. Ellis (2001: 127); also, Bird (2007) and Mumford (2010)]. Rather, for Aristotle, only the first actuality of a power possessed by a subject is potential, while powerfulness extends also to the second actuality, the activated power; in both states, the power is powerful with reference to change—it is capable of bringing about change, or is bringing about change.

The appropriate conditions for the activation of a power by another power are generically described by Aristotle as 'contact' between the two powers. Contact could be thought of as a relation between powers, but Aristotle does not think of it in such terms. Rather, he analyses contact in terms of place and limits, without there being a connection between a limit and what converges on it.

Aristotle thinks of powers as differentiated into active and passive powers, where an active power 'moves' or somehow 'operates on' the passive power. In most cases he thinks in fact that each power is at the same time both active and passive, since powers operate on each other. It is helpful to think, with Aristotle, of the operation of a mover on a movable as the transmission of the form of a power, e.g. the hot, onto a passive power. This should not be thought to be a literal description, but a figurative account that explains what results from the mutual activation of an active and a passive power. Thus, it should not be thought that when an active power activates a passive power there is an underlying physical mechanism for the

transmission of any item, such as the form of the agent to the patient power.[3] The transmission of form is a way of describing what is brought about by *causation*, as though the patient power received the form of the agent power (although nothing is actually transferred from the agent to the patient). But as we shall see, what happens is not a transmission, but an activation of the patient power by the active power.[4] Causal change, in Aristotle, results from the mere proximity of interdependent powers.

In the above I have been discussing fundamental powers rather than complex macro-powers, such as the power to build a house or to carve a statue. In the case of macro-powers it might appear that matter is transferred from the agent to the patient, e.g. the builder lays bricks to build the house. But in fact the builder is building by simply passing on the form of the house to the bricks through her movements. (Again this is a figurative description, since the builder is not actually transferring 'a form' to the bricks.) The only thing that happens in the exercise of the building power is the mutual activation of powers, whether this mutual activation is between the powers of the builder's arms and of the bricks, or between the powers of the bricks themselves, etc. For Aristotle there is nothing exchanged between the powers. Talking of the transmission of the form is only a way of describing the type of causal action of a power upon another: *as if* the form of the one was transmitted onto the other power.

Before coming to a more detailed discussion of Aristotle's position, it might be helpful to put my interpretation in a nutshell, to contrast Aristotle's views, as I understand them, to his predecessors', and to bring out the novelty of his account, not only in relation to ancient metaphysics, but for contemporary philosophy too. The Pre-Socratics described the world by introducing principles that were aimed at explaining change in nature. Movement or force gives rise to generation and change in some type of stuff or other; e.g. the hot and the cold, or condensation and rarefaction change water, or air, or amorphous stuff, or atomic formations, etc. Plato, on the other hand, focused on a problem that did not arise in the Pre-Socratics, namely the instantiation of universals in his ontology; but he

[3]Aristotle understands perception too, which is a case of causation, as being the reception of form without matter by the sense organ. For a fuller discussion of the case of perception, see Marmodoro (2014).

[4]In contemporary physics, to explain how elementary particles act on one another virtual particles are posited, as *force-carriers* (in effect, force-instances). Thus, elementary particles exert forces on each other by exchanging such virtual particles—e.g. the gauge bosons. One might think that, by introducing virtual particles to *carry* forces from particle to particle, e.g. the electromagnetic force or the weak force, contemporary physics has solved the problem of causal *efficacy* by replacing causal efficacy with *addition* to, or *subtraction* from the *constitution* of the particles (e.g. more, or less, weak force) rather than with interaction between particles. But there are reasons to think that this is not the case. Virtual particles of different types interact with one another, too. For instance, in the Standard Model, vector bosons couple with fermions, and W bosons couple with a photon or a Z^0 boson (Couchman 2000). Such couplings between virtual particles happen due to the effect of gauge bosons on gauge bosons of a different type. Such *primitive effect* between forces is what Aristotle, too, assumed in his theory of causation.

neglected to provide a metaphysical account of generation and change. He reified instantiation as the relation of participation in the Forms, which take on the role of universals among other roles. But change receives brief explanation in Plato, metaphysically as the occurrence of participation in Forms *(Phaedo* 100c–d; Aristotle, *Metaphysics* 991b3–9; *Generation and Corruption* 335b7–24), and physically as the rearrangement of elements (*Timaeus* 56c–e) (which is akin to Pre-Socratic types of explanation of change). Aristotle, by contrast, does *not* reify the instantiation of universals into a relation, nor does he reify universal forms as such, nor matter as such—and this has important implications, to be drawn in what follows, for understanding his hylomorphism. The ultimate constituents of hylomorphic compounds are not matter and form held together by relations between them. The ultimate constituents are powers, which become activated. More graphically, the bedrock of Aristotle's reality is not a two-tier hylomorphic "clasp" between matter and form; but a single tier of powers that are either in potentiality or are activated. If we are to think of a 'cosmic generator' of creation and change for Aristotle's world, it is not the coming together of matter and form into hylomorphic compounds; but rather, it is the activation of powers from potentiality to actuality [see Marmodoro (2013)].

For Aristotle, change is the activation of a passive power, whose nature is to suffer the agency of an active power. A passive power's activation (actualisation, realisation)[5] may be a process, such as becoming hotter; or an activity, such as seeing. For Aristotle, there is *change* in the case of the *process* only, since the resulting state from the process is qualitatively different from the initial state—as for instance in the case of heating (process), but not of seeing (activity).[6]

An important difference between Aristotle's account of powers and the contemporary ones is the following. In contemporary theories, the manifestation of a power is a *new* power [e.g. for Mumford and Anjum (2011)] or a new property (e.g. for Bird (2007) that comes about, e.g. an ice cube's power to cool the lemonade in the glass is manifested in the new—lower—temperature of the lemonade.[7] But for Aristotle, this is not the case. The actualisation of a power is not a new property that comes about. Rather, it is the activation of the power, either as it is exercising its influence on the passive power or as the passive power is suffering that influence. For example, if a mango has the power to ripen in the heat, the ripening is the actualisation of active and passive powers at play. The ripe state of the mango that comes about is the 'aftermath' of the activation of the powers, not their manifestation. The powers are manifested in their activity with each other, not in the state that results from their activation.

[5]I will use the terms 'activation' and 'realisation' of powers interchangeably in what follows, to describe a power's reaching the end that defines its nature.

[6]In our common sense conception of change, both process and activity count as changes. What Aristotle wishes to capture by treating only process as change is that activity does not alter the constitutional make up of the active agent, but only puts the existing constitution to work.

[7]For instance, see Bird (2007: 7): 'Potencies are characterized in terms of other properties (their stimulus and manifestation properties)'.

All that happens in Aristotle's world is that powers in potentiality come to be actualised, either as agents of change or as patients of change. Change involves the mutual activation of agent and patient powers, brought about by the contact between ontologically interdependent pairs of powers, such as e.g. what can heat and what can be heated. Powers are monadic properties, since Aristotle does not reify polyadic relations in his ontology. But powers can be ontologically dependent on each other, where ontological dependence is not a 'connecting bridge', i.e. a relation or an extra entity connecting an agent power and a patient power. In sum, nature is a cluster of interdependent powers that, when in contact, activate one another; this may result either in activity, e.g. seeing, or in a process of change, e.g. being heated.

1 Potentiality for Change

For Aristotle, there is a primary sense of potentiality from which the other senses are derived. This is the capacity to *bring about change*:

> All potentialities (*dynameis*) that conform to the same type are *starting points* of some kind, and are called *potentialities* in reference to one primary kind, which is a starting point of *change* in another thing or in the thing itself *qua* other. (*Metaphysics* 1046a9–10, my emphasis)[8]

This primary sense of potentiality is that of the capacity to bring about change in another thing or in the same thing as if it were another. The former case is the standard case of causing change, such as fire heating an object or an object in motion setting something else in motion, etc. Aristotle's qualification of causing change in the thing itself as if it were another is aimed at including complex entities which have the capacity of bringing about a change in a part or the whole of themselves, e.g. an athlete training herself.

Of course the criterion of being a cause that is the *originative* source of change would need to be relativised to a context, for otherwise one could endlessly trace back origins of change. Aristotle does not mention this issue in the passage quoted, but it is a consideration he is sensitive to, as we see from his subsequent discussion of matter and the introduction of the concept of *proximate* matter:

> It seems that when we call a thing not something else but 'of' that something else (e.g. a casket is not wood but of wood, and wood is not earth but made of earth …), that something is always *potentially* (*in the full sense of that word*) *the thing which comes after it in this series*. E.g. a casket is *not* earthen nor earth, but wooden; for wood is potentially a casket and is the matter of a casket. (*Metaphysics* 1049a18–23; my emphasis)

Aristotle's point here is two faceted. On the one hand he is introducing a strong sense of potentiality; on the other, he is associating it with a semantic/grammatical

[8]All translations of Aristotle's text are from Barnes (1995).

phenomenon. The strong sense of the term 'potentially' is to be found in the case of *adjacent* items in the series of changes—e.g. when the wood becomes a casket. The earth is not potentially a casket in this sense, because there is an intermediate step between earth and casket in the series of changes from earth to wood to the casket. So it is the wood that is strictly speaking potentially the casket in the present context, despite the fact that the wood comes from earth, and hence the casket comes from earth. This is the reason, Aristotle explains, for the corresponding semantic/grammatical point, that is, why we call the casket 'wooden' but not earthen. For corresponding reasons, in any given change, the origin of the change, i.e. its cause, will be taken to be the immediate cause of this particular change in question, rather than an antecedent one in the causal history of this change.

A second type of potentiality Aristotle includes in his ontology is the capacity to *suffer change*:

> For one kind is a potentiality for being acted on, i.e. the principle in the very thing acted on, which makes it capable of being changed and acted on by another thing or by itself regarded as other. (*Metaphysics* 1046a11–13)

We might not be immediately ready to acknowledge the capacity to suffer change as a power; but it only takes some reflection to see that we do have some terms in everyday language that pick out just such capacities or powers, e.g. 'fragility', or 'malleability', or 'flexibility', etc. For Aristotle being able to change is as much a capacity or power as being able to effect change:

> In a sense the potentiality of acting and of being acted on is one (for a thing may be capable either because it can be acted on or because something else can be acted on by it), but in a sense the potentialities are different. For the one is in the thing acted on; it is because it contains a certain motive principle, and because even the matter is a motive principle, that the thing acted on is acted on … for that which is oily is inflammable, and that which yields in a particular way can be crushed; and similarly in all other cases. But the other potency is in the agent, e.g. heat and the art of building are present, one in that which can produce heat and the other in the man who can build. (*Metaphysics* 1046a19–28)

A notion that is peculiar to Aristotle's account is conceiving of passive powers as originative sources of change (1046a11–13; a23). It is natural for us to think that an originative source of change is a power to *bring about* change; but it is not as natural to think that an originative source of change is a capacity to *suffer* change. Yet Aristotle sees both active and passive powers as originative sources of change, the one as a source that changes something, and the other as a source of suffering change. In fact, Aristotle gives several examples of originative sources of suffering change to make his point clear, such as for example, oil or brittle matter.

The distinction between the active and the passive capacities or powers also serves to set up the conditions under which change takes place. This is determined in the *definition of a capacity*. What is specified in the definition of a capacity is: the *type* of capacity the capacity in question is, namely what it is that it can do, i.e. bring about or suffer; the appropriate *occasion* in which the capacity can do this; the *way* in which it can do it; and any other *conditions* that need to obtain for it to do what it does. When all the conditions set out in the definition are met, including the

active and passive powers coming in *contact*, in the relevant sense of contact for the type of power they are, then *necessarily* the agent power acts on the passive power and brings about its effect:

> Since that which is capable is capable of something and at some time in some way – with all the other qualifications which must be present in the definition–, … as regards potentialities of … [those things that are non-rational; e.g. the fire] … when the agent and the patient meet in the way appropriate to the potentiality in question, the one *must* act and the other be acted on … For the non-rational potentialities are all productive of one effect each. (*Metaphysics* 1047b35–1048a8; my emphasis)

The necessity is natural necessity, stemming from the nature of the capacities/powers themselves, on satisfaction of the conditions in the definition of their natures. Aristotle did not talk of laws of nature. Yet, it is clear from the normativity expressed in this passage, that the definitions of powers determine the conditions whose satisfaction is the instantiation of laws of nature.

2 Causal Agency

We must now come to examine and try to comprehend the nature of the *agency* of the capacity/power of a mover on the capacity/power of the movable. There are two aspects of a mover's causal agency that reveal its nature. The one is what it brings about, and the other is how it achieves it. Aristotle describes what the mover does to the movable in terms of the transmission of the form of the moving power:

> The mover will always transmit a form, either a 'this' or such or so much, which, when it moves, will be the principle and cause of the motion, e.g. the actual man begets man from what is potentially man. (*Physics* 202a9–12)

So the form could be a substantial form, as in the case of the transmission of the form of a human being to the menstrual fluids in the generation of an embryo; or it could be a quality, a suchness, as for instance heat or weight, etc. But what does it mean to say that the form of the moving power is transmitted? Aristotle wants to find a way to explain the change that is brought about by the moving power. In his example above, the generation of a new human being is accounted for by the transmission of the form of a human being, which is the principle and the cause of the motion. The form transferred is the form that determines the end/goal (*telos*) of the potentiality in the moving power's definition. Thus a parent has the potentiality to generate a human being, and a painter the potentiality to generate a painting on canvas. These are the ends that the movers' powers are directed towards, in their potential state, e.g. the ends that the parent and the painter have respectively. They express what the powers can bring about when actualised. Aristotle's explanation of causation in terms of the transference of a form from the moving power to the passive one should not be taken as a literal but a figurative description. Aristotle is not reifying the form of the power into an active agent of its own, over and above the power. There is no homunculus-form that is transmitted from the parent to the

offspring. There are only motions transmitted from the parent to the menstrual fluids by the sperm that is implanted in them; the heat in the parent's sperm generates the motions in the fluids, which gradually shape the embryo, as Aristotle tells us explicitly (See Aristotle, *Generation of Animals* II.2–3). Similarly, there is no form of a statue that is literally transferred from the sculptor to the marble; a sculptor transfers the form of a figure in her mind to the marble through the movements of her hands and chisel. Nevertheless, talk of transmitted forms is the best way to *describe collectively* the type of effect that the respective moving powers have on the passive ones. The movements generated from the heat of the sperm in the first case, and from the hands of the sculptor in the second bring about changes of particular types, which are determined by the kind of moving power that is acting on the passive one. The resulting change is *as if* the sperm transferred a form onto the menstrual fluids, which en-formed them and shaped them into an embryo; and *as if* the sculptor transferred a form onto the marble which en-formed it into a statue. There is no such magic; Aristotle's account is cogent and intuitive. Macro-changes emerge from micro-changes brought about by the fundamental powers (i.e. as we will see, the hot, the cold, the wet and the dry), which affect their passive correlates. Even if one took Aristotle to be saying that, literally, there is a (reified, matter-less) form that is transmitted to the passive power, this would still *not* explain how causation takes place. We would want to know how that form does it; what causal efficacy a form can have on a passive power. Assuming Aristotle is looking for an answer as to *how* a power affects another, adding a further item to the causal series would not offer an explanation. It would only continue the regress generated in the search for the mechanism of causal efficacy.

Then how does causal efficacy operate? Even if macro-level powers depend on micro-level powers to bring about their effects, how do micro-level powers exert their causal efficacy on other micro-level powers? As we shall see, Aristotle avoids the regressive series of introducing further intermediaries by assuming the *efficacy* of a moving power on a passive one; all that happens is that 'when the agent and the patient meet in the way appropriate to the potentiality in question, the one *must* act and the other be acted on' (*Metaphysics* 1048a6–7). The transference of the form of the moving power to the passive one is not a description of the mechanism of causal efficacy, but only a collective description of the type of qualitative change that takes place in the passive power. Examining closely the behaviour of active and passive powers will help us understand how this change is effected.

3 Stimulus and Appropriate Conditions

Aristotle acknowledges that there is a variety of what we would call *enabling conditions* for the activation of a power, pertaining to the right time, the right situation, the right external conditions; he summarises them in saying that the mover is capable of something 'at some time in some way (with all the other qualifications which must be present in the definition)' (*Metaphysics* 1048a1–2).

On the other hand, he collectively describes the *stimulus* that triggers powers that are in the right circumstances into causal activity by the general condition of 'contact' between them:

> To act on the movable as such is just to move it. But this it does by contact, so that at the same time it [the mover] is also acted on. Hence motion is the fulfilment of the movable as movable, the cause being contact with what can move, so that the mover is also acted on. (*Physics* 202a5–9)

So contact is the triggering condition, along with all the other conditions mentioned in the definition determining the enabling conditions for causal efficacy to take place. It is therefore important to come to understand what is involved in the contact between the active power and the passive power it operates on. Aristotle tells us that:

> Things are said to be in contact when their extremities are together. (*Physics* 226b23)

He further explains that

> Things are said to be together in place when they are in one primary place and to be apart when they are in different places.[9] (*Physics* 226a21–3)

So things that are in contact have their extremities in the same place. For the purposes of causation, having the extremities in the same place will have to be understood as either touching or being in proximity, since there appear to be cases where there is causal impact even when things are merely proximate, namely, in the same place in the sense of same spatial region. For example, proximity to a fire is sufficient for heating, and even for catching fire.

We saw above that for Aristotle to act on the movable is to move it, and that this is achieved by contact. In examining his concept of contact as defined, we see that the contact between mover and movable involves the coincidence of place of the extremities of the mover and the movable, e.g. the chisel of the sculptor and the wood, or the flames of the fire and the pot resting on it. But once contact is achieved, what does the operation of the mover on the movable involve? Is it something over and above the contact between them, and if so, what? Is there a relation established from the mover to the movable that is responsible for the change the movable suffers, or is there a different mechanism of causal interaction? The answer to the question of how the mover operates on the movable and brings about change will not for Aristotle involve positing any 'bridge', relation or connection from the mover to the movable. He grounds his theory of causation in his account of relations in terms of monadic properties and counterfactual dependence. To this I now turn.

[9]Aristotle defines place as 'the innermost motionless boundary of what contains' (*Physics* 212a20–21).