# Pathology as Reduced Efficiency
## A Dispositional Approach

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RESUMEN

Este artículo aborda la cuestión de si la "patología" puede definirse en términos de reducción de la eficiencia. Para ello, discuto la noción de eficiencia en la teoría bioestadística de Boorse (1997), por ejemplo, y la teoría de la eficiencia funcional de Hausman (2012), y defiendo que, mientras que Boorse no proporciona una definición precisa, la definición de Hausman no es adecuada para aplicarla en las evaluaciones de la salud. Propongo entonces una definición precisa de "eficiencia" e ilustro su uso en las evaluaciones de salud. También muestro cómo la definición sugerida contribuye a resolver el dilema de Kingma (2010).

PALABRAS CLAVE: *eficiencia, patología, enfermedad, salud, disposiciones, teoría bioestadística*.

ABSTRACT

This paper deals with the idea that 'pathology' can be defined in terms of reduced efficiency. I discuss the notion of efficiency in Boorse's biostatistical theory (e.g. 1977) and Hausman's functional efficiency theory (2012) and argue that whereas Boorse does not provide a precise definition, Hausman's definition is not suitable to apply in health evaluations. I then propose a precise definition of 'efficiency' and illustrate its use in health evaluations. I also show how the suggested definition contributes to solving Kingma's dilemma (2010).

KEYWORDS: *Efficiency; Pathology; Disease; Health; Dispositions; Biostatistical theory*.

## I. INTRODUCTION

A standard idea among naturalistically oriented theories of pathology is that a trait token of an organism is pathological only if it is dysfunctional. Whereas some take dysfunction to be a necessary but not sufficient requirement for pathology [e.g. Wakefield (2014)], others take it to be

both a necessary and sufficient requirement [e.g. Boorse (1977)]. In this paper I will focus on the view that dysfunction is both necessary and sufficient for pathology. I will also limit my focus to theories embracing a goal-analysis of physiological function; that is, where physiological functions are analyzed as causal contributions to certain goals, e.g. survival and reproduction. Among these theories, 'dysfunction' is commonly defined with reference to a notion of efficiency, which is supposed to describe how well trait tokens function: a too low efficiency means that the trait token is dysfunctional. The first to formulate this sort of idea is Boorse (1977).

How to understand the notion of efficiency in the context of health status evaluations is, however, not clear. Boorse (e.g. 1977) gives some indications, but does not provide a precise definition. Hausman (2012) adds some more discussion of the issue and provides a more precise definition. However, although Hausman makes important progress, his definition is not suitable for health status evaluations.

The aim of this paper is to develop a precise definition of 'efficiency' and illustrate its use in health status evaluations. This is of importance, because whether the idea that pathology consists in too low efficiency really works out depends on whether it is possible to spell out the notion of efficiency in some reasonable way. The primary purpose in this paper is to develop a theoretically sound naturalistic theory. Hence, practical applicability is of subordinate interest.

The paper is structured as follows. Sections II and III discuss the notions of efficiency in Boorse's and Hausman's respective theories. Section IV develops an alternative account of efficiency, which is free from the problems of Boorse's and Hausman's accounts. Section V shows how this account contributes to solving Kingma's dilemma, a much-discussed objection against naturalistic theories. Section VI concludes.

## II. BOORSE ON EFFICIENCY

Boorse discusses his "biostatistical theory" (BST) in a number of works [(1977); (1987); (1997); (2014)]. In his latest publication on the BST, the definitions of 'health' and 'pathology' are the same as in his first paper (although the term 'pathology' has been substituted for 'disease'):

> *Health* in a member of the reference class is *normal functional ability*: the readiness of each internal part to perform all its normal functions on typical occasions with at least typical efficiency.

> A *disease* [later, *pathological condition*] is a type of internal state which impairs health, *i.e.,* reduces one or more functional abilities below typical efficiency [Boorse (2014), p. 684, italics and brackets are original].

In these definitions, the notion of efficiency has the role of enabling evaluations of how well trait tokens function physiologically. Boorse defends an analysis of physiological function where the basic idea is that physiological functions are causal contributions to the goals of survival and reproduction [c.f. Boorse (1976), p. 84]. So, functioning well is to be assessed with reference to survival and reproduction.

Observe that in the definition of 'health', efficiency is stated as a feature of performances of physiological functions, relative to occasions. In the definition of 'pathology', however, it is stated as a feature of functional abilities. Although this is a terminological difference, I think we should give the terms a homogenous understanding. This is because Boorse's idea is that a pathological condition stands in direct opposition to health — it is "a type of internal state that *impairs health*". So, I suggest that we here understand a functional ability as a potential performance in a certain potential situation.

Boorse explains that efficiency is about the serving of physiological goals, which he takes to be survival and reproduction [(1977), p. 559]. For example, a thyroid performing very efficiently, according to Boorse, is a thyroid that serves the goal of survival very well, i.e. a thyroid that secretes an adequate amount of thyroid hormones for the current metabolic needs. It is, however, not clear from Boorse's writings how to understand efficiency more precisely. First, Boorse does not suggest a unit of measurement for the physiological goals. Second, given such a unit, it is not clear how to measure how efficiently a trait token's performance serves the goals. One problematic aspect here is that the notion of efficiency, on the BST, concerns both survival and reproduction. This is problematic even if we define separate measures for survival and reproduction. The reason for this is that a trait token's performance of a physiological function may serve the possessor's survival better in comparison to the reference class, than it serves the possessor's reproduction in comparison to the reference class (or vice versa). For example, think of a human female at age 23, whose hypophysis' secretion of hormones is abnormal in a way that makes her ovulate very infrequently. The abnormal hormone levels do, however, not affect her notably in any other way. Here, the hypophysis' abnormal secretion of hormones makes

her worse off with regard to reproduction, relative to her reference class, but not worse off with regard to survival, relative to her reference class. If Boorse's notion of efficiency is to make sense, it must include some weighing of survival and reproduction. But it is not obvious that there is a reasonable, non-arbitrary, weighing to formulate here.

Lastly, I will mention a much-discussed problem for the BST, which we will see is important to bear in mind when improving on Boorse's notion of efficiency. This is the problem of common diseases [Schwartz (2007), pp. 375-376]. According to the problem of common diseases, the BST cannot account for diseases that are common in a reference class. This is because it defines health as "normal functional ability", where "normal" is spelled out in terms of statistical typicality [Boorse (1977), p. 557]. Some examples of common diseases, provided by Schwartz (2007), p. 375, are: a certain dysfunction of the hip joint in dogs (canine hip dysplasia) estimated to be present in 30 percent of the population in some breeds, and urinary dysfunction in humans due to benign prostatic hypertrophy estimated to occur in more than 17 percent of men older than 70.

III. HAUSMAN ON EFFICIENCY

Hausman (2012) suggests his "functional efficiency theory" as an improvement of Boorse's theory. His main point is that health and pathology should not, as in the BST, be distinguished with reference to statistical normality, since such a distinction generates the problem of common diseases. First, when accounting for the standard for health, Hausman (2012), p. 536, refers to what is readily attainable for many individuals of the reference class, rather than what is statistically typical. By this move he allows that more than half of the trait tokens in a reference class function worse than the standard. For example, Hausman thinks that "the possession of a complete set of teeth with no decay or other defects" [(Ibid., p. 536] is readily attainable for humans today. This means that, even if most humans develop cavities due to a non-optimal diet, the standard for healthy teeth is to have no cavities. Second, Hausman denies that the distinction between health and pathology should be statistically defined. Rather, health status evaluations concern the relation between a trait token and the standard [Ibid., pp. 536-537].

Having considered Hausman's strategy for solving the problem of common diseases, let us now return to the issue of how to understand

efficiency. Hausman points out that Boorse "says little about what defines efficiency" [(2012), p. 530], and suggests the following definition:

> On the assumption that the other parts of the organism or systems whose activities do not depend on [the set of capacities] C or [the set of capacities] C′ are functioning adequately in a relevant environment,

> The functional efficiency of C is greater than that of C′ in some system S with respect to some goal G if and only if C makes it more likely that S achieves G than does C′. [Hausman (2012), p. 534]

This definition of 'efficiency' is different from Boorse's, first, in that Hausman defines 'efficiency' as a feature of sets of capacities, rather than of performances. Second, Hausman does not, as Boorse, limit the system to an organism, or the goals to survival and reproduction. However, it is clear that he takes organisms to be relevant systems, and survival and reproduction to be relevant goals for health status evaluations [Hausman (2012), pp. 521, 535].

Hausman improves on Boorse's notion of efficiency with regard to all of my complaints in Section II. First, Hausman specifies the serving of physiological goals as the likelihood to achieve a goal G. Second, that one set of capacities C is more efficient than another set of capacities C′ is clarified as C making it more likely than C′ that the concerned system achieves G. Third, since Hausman's definition makes efficiency relative to a particular goal, there is no need to formulate a principle for weighing the goals of survival and reproduction. Rather, we may talk both about a trait token's efficiency relative to a goal of survival and its efficiency relative to a goal of reproduction.

Hausman's definition of 'efficiency' is, however, not suitable to apply in health status evaluations. The reason for this is twofold. First, it is questionable whether measuring efficiency in terms of the likelihood to achieve a certain goal always makes sense in health status evaluations. Consider the goal of survival. Just "achieving survival" is a too unspecific goal for meaningful efficiency comparisons. To be more specific, one could consider the likelihood to survive for a particular time interval. When evaluating treatments for cancer, one typically considers progression-free survival of certain time intervals (e.g. one year). However, health status evaluations do not only require considerations of the likelihood to survive for a certain interval of time, but considerations of likelihoods to survive for all different time intervals. To see this by an example, consider the individuals Astrid and Beatrice, both 20 years old.

The capacities of Astrid's heart give higher chances of surviving for one year than the capacities of Beatrice's heart. But the capacities of Beatrice's heart give higher chances of surviving for 20 years than the capacities of Astrid's heart. Here we may conclude that the capacities of Astrid's heart are more efficient than those of Beatrice's heart, relative the goal of surviving for another year, but that the capacities of Beatrice's heart are more efficient than those of Astrid's heart, relative the goal of surviving for another 20 years. But it is unclear whether we should say that Astrid's or Beatrice's heart is more healthy.

The second reason why Hausman's definition is not suitable to apply in health status evaluations is that it only defines 'efficiency' comparatively. Hausman provides us with an ordinal scale for measuring efficiencies, which allows us to rank the efficiencies of different sets of capacities. This makes it possible to draw a general line distinguishing health from pathology based on statistical normality. One could for instance say that the 2,5 percent of the tokens of a trait type in the reference class with the lowest efficiencies in the ranking are pathological. However, this is precisely the sort of line-drawing Hausman argues against, since such a line-drawing generates the problem of common diseases. Yet, with only an ordinal scale of efficiencies, it is doubtful whether one may non-statistically distinguish health from pathology. In order to do that, it seems that we need to measure efficiency on an interval or ratio scale.

In Hausman's defense, his goal is not to define an absolute distinguishing line between health and pathology. Rather, Hausman expresses doubts towards the usefulness of such a line [(2012), p. 534]. However, even if it is not important to make an exact distinction between health and pathology, we still want to be able to make more comparisons between different efficiencies than Hausman's account allows for. On Hausman's account, we may conclude about three trait tokens of the same type that one of them functions best, another second best, and the third worst. However, we cannot evaluate how much worse the second best and the worst function in comparison to the best functioning token. Another limitation concerns comparisons of trait tokens of different types. It is not clear whether C and C´ in Hausman's definition must be capacities of the same type. If they must, we cannot compare the capacities of tokens of different trait types. If C and C´ may represent capacities of different types, then we can compare the capacities of trait tokens of different types; however, not in the relevant sense. We may conclude that a specific heart's capacity to pump blood has a higher efficiency

then a certain muscle's capacity to abduct the thumb, since the heart's capacity to pump blood makes it more likely that the individual achieves a certain goal, say becoming 80 years old, than does the muscle's capacity to abduct the thumb. But this is not the sort of comparison we are interested in. We do not want to say that a normally functioning muscle in the hand functions worse than a normally functioning heart just because the heart plays a more central role in the survival of a human. Rather, what we are interested in is a comparison between, on the one hand, how the specific heart's capacity to pump blood relates to a standard for pumping blood, and, on the other hand, how the specific muscle's capacity to abduct the thumb relates to a standard for abducting the thumb. This sort of comparison cannot be made on Hausman's account.

Lastly, we may note an unclarity in Hausman's account. In the above definition, Hausman explicitly makes comparative efficiency relative to exactly one system. When determining the comparative efficiency of two sets of capacities C and C′, these are seen as alternative sets of capacities of one and the same system S. This is, as I will argue in Section IV, a good idea. However, Hausman does not explain how to compare two sets of capacities as alternative sets of one particular system. And in his concrete examples, he does not really incorporate the idea. It is, for instance, not clear in the following example how Jill's heart and Joan's heart are compared as alternative hearts of one and the same organism:

> […] systems or organisms with higher levels of functional efficiency are, with regard to the particular part or process, healthier, and systems or organisms with lower levels of functional efficiency are less healthy. For example, if Joan's heart enables her to walk upstairs easily, while Jill's does not permit her to walk across the room without stopping to catch her breath, Joan's heart is healthier. [Hausman (2012), p. 534]

In this example, it sounds as if what is compared is, on the one hand, Joan's heart as part of Joan and, on the other hand, Jill's heart as part of Jill. But if we compared Joan's and Jill's respective hearts as alternative parts of one and the same system, we would have to view them as alternative hearts of Joan, or as alternative hearts of Jill, or as alternative hearts of some third individual.

Let us summarize. Hausman makes progress in developing Boorse's notion of efficiency. However, his definition leaves us with three problems to solve. First, measuring the physiological goals by the likelihood to achieve a goal G makes the notion of efficiency too narrow. It is for example not possible to take into account the likelihoods to survive for

several different time intervals in one efficiency evaluation. Second, since Hausman only defines 'efficiency' on an ordinal scale, we are not able to make all relevant comparisons between different sets of capacities. Third, it is not clear how to compare two sets of capacities as alternative parts of one specific system (e.g. a specific organism).

## IV. DEFINING 'EFFICIENCY'

I will now suggest a definition of 'efficiency', which solves the problems with Hausman's definition. Similarly to Hausman's account, a particular efficiency evaluation will not concern both survival and reproduction at the same time. For reasons of clarity, I will distinguish between two different efficiency notions: survival-efficiency and reproduction-efficiency. I will then also distinguish between two pathology concepts: survival-pathology (defined in terms of reduced survival-efficiency) and reproduction-pathology (defined in terms of reduced reproduction-efficiency). For reasons of limited space, I will only discuss survival-pathology. But the thought is that we can define 'reproduction-pathology' analogously to how we define 'survival-pathology'.[1]

In order to define survival-efficiency, we need a unit in which to measure the goal of survival. A reasonable unit for this is "further life expectancy", i.e. for how long the organism is expected to continue living. In contrast to Hausman's account, this unit takes into consideration the likelihoods to survive for all different time intervals. Importantly though, the determination of an organism's further life expectancy must not take into consideration available special medical or social interventions, e.g. medical surgery, physio– or psychological therapy, personal assistance, usage of hearing aids. This is because what we are interested in when determining the health status of a trait token with a certain condition is whether that condition reduces further life expectancy if not treated or compensated for.

Boorse and Hausman, we saw, differ in whether they take efficiency to be a feature of performances or sets of capacities. In the account of efficiency being developed here, efficiency will be a feature of dispositions. "Dispositions" here are similar to Hausman's "capacities". I will assume that each trait token in an organism, for each of its type's physiological functions, is disposed to react in certain ways in certain situations. I will model such dispositions as tables reporting, for each possible situation, how the trait token will perform the physiological function. A reason

to define 'efficiency' as a feature of dispositions, rather than of performances, is that it makes more sense to measure an organism's further life expectancy based on information about how its different trait tokens are disposed to perform in different possible situations, than merely on information about how its trait tokens perform in one particular situation.

The efficiency measure that I will develop is similar to Hausman's definition in that it compares two dispositions as alternative parts of one and the same system. Here, the system is always an organism. I will represent the functioning of an organism as a configuration of dispositions — one for each physiological function in the organism. The idea is then that we evaluate the survival-efficiency of a trait token's disposition for performing a certain physiological function as follows: we consider how the further life expectancy of a standard organism for the trait token bearer's reference class is affected if we substitute its disposition for performing the physiological function in question with that of the trait token under evaluation.

I will in the following subsections (IV.1 – IV.4) provide a model in which survival-efficiency can be precisely defined. I will then show how to use this definition in health status evaluations (IV.5). I call the whole theory of efficiency, health, and pathology 'the disposition profile efficiency theory', abbreviated 'the DPE-theory'.

IV.1 *Disposition Profiles*

As indicated above, I will model dispositions as tables reporting, for each possible situation of a trait token, how the token will perform a physiological function. Several values may be needed to represent this. For example, in order to describe how the heart pumps blood in a certain situation, one may have to consider both its beating frequency and contraction force. I will call the values that together report how the trait token performs the physiological function in a possible situation a 'value configuration'. By a 'situation', I mean a possible state of the world, but excluding the value configuration of the disposition in question.

The idea is illustrated by the following table (where each $S$ is a situation, and each $v$ and $v'$ are values reporting on beating frequency and contraction force, respectively):

|  | $S_1$ | $S_2$ | ... | $S_n$ | ... |
|---|---|---|---|---|---|
| Beating frequency | $v_1$ | $v_2$ | ... | $v_n$ | ... |
| Contraction force | $v'_1$ | $v'_2$ | ... | $v'_n$ | ... |

Let us call such tables 'specific disposition profiles' and define them as follows:

> A **specific disposition profile** for a physiological function $F$ is a function $dp$ from situations to value configurations such that $dp(S)$ is a value configuration for $F$ for each situation $S$.

Some trait types are associated with more than one physiological function. In such cases, the trait tokens have several specific disposition profiles, one for each physiological function.

In line with what I said above, the functioning of whole organisms will be represented by configurations of specific disposition profiles. Let us define 'complete disposition profiles' as follows:

> A **complete disposition profile** for a set $P$ of physiological functions is a function $DP$ from $P$ to specific disposition profiles such that $DP(F)$ is a specific disposition profile for each physiological function $F$ in $P$.

In the following, I will use the abbreviations 'SDP' for 'specific disposition profile', and 'CDP' for 'complete disposition profile'.

We may then also define a function *fle* from CDPs to non-negative real numbers such that *fle*$(DP)$ represents the further life expectancy for an organism with the CDP $DP$. I will not provide a specific unit for measuring further life expectancy. What is a suitable unit for measuring this (e.g. seconds, days, or years) may vary from one particular survival-efficiency evaluation to another.

IV.2 *A Reference Class-Relative Standard*

When we evaluate the survival-efficiency of a disposition we consider how the further life expectancy of a standard organism for the trait token bearer's reference class is affected if we substitute its disposition for performing the physiological function with that of the trait token under evaluation.

The thought behind evaluating the survival-efficiency of a disposition in the context of a standard organism for the reference class is that the notion of pathology is reference class-relative. We find indications of this in medical theory. If we look at physiological theory, we find descriptions of the functioning of healthy organs and systems for groups of similar individuals, rather than for particular individuals. And looking at

pathological theory, more or less typical impairments of these types of organs and systems, resulting in pathology, are described. When it is claimed that a trait token is pathological, what is claimed is typically that the trait token does not meet the standard for its trait type, rather than that the trait token does not meet the individual organism's standard for that trait token. If one would hold that health and disease are individual-relative properties, one would have to admit that what is presented as a healthy heart for a specific reference class in physiology may not always be a healthy heart – whether it is or not is relative to the individual organism.

A reference class-relative standard obviously requires reference classes. However, it has been contested whether it is at all possible to give a naturalistic account of reference classes [c.f. Kingma (2007)]. For reasons of limited space, I will not go into detail about reference classes in this paper, but just assume that it is possible to naturalistically define relevant reference classes for health status evaluations. It may be clarified, though, that these reference classes need only be relevant comparison classes for health status evaluations. They need not carve nature at its joints, or function as general divisions in biology.

In line with Hausman's solution to the problem of common diseases, the standard should not be the statistically defined. When accounting for the reference class-relative standard organism, I will follow Hausman's idea but adapt it to the framework developed here and introduce some further precision. Recall that organisms are represented by CDPs. I will call the standard CDP relevant for survival-efficiency the 'survival-exemplary CDP'. Roughly and informally, that a CDP is survival-exemplary means that the CDP will give a member of the reference class as high further life expectancy as possible, subject to reasonable constraints.

I define a survival-exemplary CDP, relative to a reference class and common environments of that reference class, as follows:

A CDP *DP* is **survival-exemplary**, relative to a reference class *R*, if and only if

out of the CDPs that are readily attainable for a significant share of the organisms in *R* in common environments for members of *R*, *DP* gives the highest further life expectancy.

Let me comment on some parts of this definition. The use of the term 'readily attainable' is rather technical. By saying that a configuration of SDPs is readily attainable for an individual, I mean that there is, among a

set of relevant close nearby possible worlds, at least one world where the individual has the configuration of SDPs. Since we should not take into consideration special medical and social interventions when determining health statuses, only worlds which do not contain such interventions are relevant. So, the set of possible worlds that determine whether a CDP is readily attainable for an individual is a set of fairly nearby worlds, except for those worlds that contain special medical or social interventions directed towards the individual. What counts as fairly close is of course a question of degree. At which distance to draw the line determining which worlds that are to be included I take to be partly a matter of convention.

Observe that this technical explication of 'readily attainable' means that if a configuration of SDPs is readily attainable for an individual, this does not mean that the configuration is possible for the individual to obtain in the future. Rather, it means that the individual could have had that configuration of SDPs. To illustrate this by a concrete example, consider a human individual who has smoked for quite some time. Because of her smoking, her lungs are scarred. Alveoli that have taken damage from smoking do not heal from that damage. Hence, the smoking cannot be undone. Yet, it may still be readily attainable, in the relevant sense, for this individual to have lungs not scarred by smoking.

Note that by using the notion of readily attainable, rather than the notion of statistical normality, the standard becomes non-statistical. What is readily attainable for a significant share of the reference class members may be more beneficial for a high further life expectancy than the average functioning in the reference class.

What counts as a significant share of the individual organisms in a reference class, I also take to be a matter of convention.

The definition refers to common environments. I take environments to be less fine-grained than situations. So, a certain environment may be instantiated by several different situations. One way to think about common environments, then, is as sets of statistically likely situations. Although there are probably no situations which are literally likely, some situations are more likely than others. For a human reference class, a situation of being in 18 degrees Celsius, being in a wind of 3 meters per second, and having a chewed sandwich in one's stomach, is more likely than a situation of being in 18 degrees Celsius, being in a wind of 3 meters per second, and having a certain poison in one's stomach. At which (low) probability level to draw the line telling whether a situation is likely or not, I take to be a matter of convention.

IV.3 *Manipulating the Standard*

As described above, an evaluation of an SDP's survival-efficiency requires that we manipulate a survival-exemplary CDP with that SDP. This means that we substitute the survival-exemplary CDP's SDP, for the physiological function that the SDP under evaluation is an SDP for, with the SDP under evaluation. Say, for example, that we evaluate the survival-efficiency of Curt's red bone marrow's SDP for producing blood cells. We then take the survival-exemplary CDP of Curt's reference class and change this CDP's SDP for producing blood cells to be exactly like Curt's red bone marrow's SDP for this function. Suppose that Curt has acute myeloid leukemia. This means that his red bone marrow's capacity to produce red blood cells, platelets, and some white blood cells is severely reduced in comparison to the survival-exemplary CDP. The manipulated survival-exemplary CDP will then also be unable to produce red blood cells, platelets, and some white blood cells.

However, the manipulation of the survival-exemplary CDP requires further complication. It will sometimes have to involve further changes of the survival-exemplary CDP than with regard to the survival-exemplary CDP's SDP corresponding to the SDP under evaluation. As described above, an SDP delivers, for each possible situation, a value configuration reporting how the trait token performs the concerned physiological function. Note that since a situation is a possible state of the world, but excluding the value configuration of the SDP under evaluation, it is not limited to the external environment of the organism, but includes the feature values of all other SDPs in the CDP. This means that formal conflicts may arise when changing the survival-exemplary CDP's SDP. For example, suppose that we evaluate the survival-efficiency of an SDP for the physiological function A. Suppose that the value configuration that the SDP for A delivers varies with the value configuration for another physiological function B. Suppose also, conversely, that the value configuration that the SDP for B delivers varies with the value configuration for A. Let us suppose that the dependence between the SDP for A and the SDP for B is the following: for any value $x$ that the SDP for B takes, the SDP for A also takes the value $x$, and for any value $y$ that the SDP for A takes, the SDP for B takes the value $(y + 1)$. Here I assume that the values are measured using real numbers. In this example we get a formal conflict. There are no values for $x$ and $y$ such that $y = x$ and $x = y + 1$.

If we consider CDPs of existing individuals, we will find no formal conflicts. No physiologically possible organism is represented by a CDP that is inconsistent in the above sense. Exemplary CDPs, although they

need not be instantiated by any individual, must also be consistent: a formally inconsistent CDP cannot be readily attainable for any individual. But, when changing some SDP in a CDP, formal conflicts may arise. When this happens, the manipulation of the survival-exemplary CDP must include further changes than with regard to the SDP for the physiological function of the trait token under evaluation to the point where the manipulated CDP is consistent. Importantly, such changes should be as limited as possible, and they must not regard the SDP of the trait token under evaluation.

  Let us express this in formal terms.

A CDP *DP´* is a CDP *DP* **manipulated with an SDP** *dp* if and only if

  (i) *DP´* is consistent,
  (ii) *DP´(f(dp))* = *dp*, where *f(dp)* is the physiological function that *dp* is an SDP for,
  (iii) given (i) and (ii), *DP´* is maximally similar to *DP*.

As we can see in this definition, a principle for the manipulation of a CDP is that the changes, besides the change of the SDP for the physiological function of the SDP under evaluation, should make the manipulated CDP maximally similar to the original CDP. Precisely how to understand "maximally similar" is a difficult issue, which I will not go into detail about here. However, the similarity considerations should at least include comparisons of the values in the respective CDPs' SDPs' value configurations.

  It is not theoretically impossible that an organism belongs to more than one reference class, and that there for each of those reference classes are several survival-exemplary CDPs, and that there for each of those survival-exemplary CDPs are several possible CDPs that may result from a manipulation of the CDP with regard to a certain SDP. There are ways to handle these possibilities, which I hope to discuss elsewhere. For reasons of limited space, I will in this paper assume that there for each SDP *dp* is exactly one reference class to which its bearer belongs, exactly one survival-exemplary CDP for this reference class, and exactly one CDP resulting from a manipulation of the survival-exemplary CDP with *dp*.

IV.4 *Defining survival-efficiency*

Let us now define 'survival-efficiency'. So far, I have said that the efficiency measure consists in a comparison between the further life expectancy of two CDPs. A natural way to carry out this comparison is by division. We divide the further life expectancy of the survival-exemplary CDP manipulated with the SDP of the trait token under evaluation, by the further life expectancy of the survival-exemplary CDP. In the below definition, I denote the reference class to which the organism with the SDP *dp* belongs '$R(dp)$', I denote the survival-exemplary CDP of the reference class $R$ '$Ex_s(R)$', and I denote the CDP *DP* manipulated with regard to the SDP *dp* '$M(DP, dp)$'.

The **survival-efficiency** of an SDP *dp*, denoted $eff_s(dp)$, is defined as follows:

$$eff_s(dp) = \frac{fle(M(Ex_s(R(dp)), dp))}{fle(Ex_s(R(dp)))}$$

According to the above definition, $eff_s(dp)$ is a non-negative real number. If $eff_s(dp) = 1$, it means that the survival-efficiency meets the standard. A value < 1 means that the survival-efficiency does not meet the standard. And a value > 1 means that the survival-efficiency is above the standard.

Let us, for illustrative purposes, return to the example about Curt, who has acute myeloid leukemia. Acute myeloid leukemia is a serious disease. Typical symptoms are tiredness, fever, night sweats, skeletal pain, and prolonged infections. If not treated, acute myeloid leukemia leads to death within weeks or months. Let us evaluate the survival-efficiency of Curt's red bone marrow's SDP for producing blood cells. Suppose that Curt is 60 years old. Suppose also that the further life expectancy for the survival-exemplary CDP of Curt's reference class is 20 years. Since the survival-exemplary CDP manipulated with Curt's red bone marrow's SDP for producing blood cells represents an individual with acute myeloid leukemia, let us estimate the further life expectancy of this CDP to 0,2 years. We then get:

$$eff_s(\text{Curt's red bone marrow's SDP}) = \frac{0,2}{20} = 0,01$$

Hence, the survival-efficiency of Curt's red bone marrow is 0,01.

IV.5 *Survival-Pathology as Reduced Survival-Efficiency*

Let us now consider the survival-efficiency measure in survival-health status evaluations. In contrast to Hausman, the DPE-theory will account for survival-health and survival-pathology as binary notions, rather than comparative.[2] In accordance with Hausman (2012), I will not base the distinction between survival-health and survival-pathology on statistical normality in the reference class. Rather, I will define the line distinguishing survival-health from survival-pathology as determined by a relation between the trait token under evaluation and the standard. The idea is that a trait token is survival-pathological if and only if at least one of its SDPs for the physiological functions for its type has a survival-efficiency that is too low. Let $k_s$ be a constant real number that represents the distinguishing line. We, then, have the following definition of 'survival-pathology':

> A trait token *a* is **survival-pathological** if and only if at least one of its SDPs *dp* for a physiological function for *a*'s trait type is such that $\mathit{eff}_s(dp) \leq k_s$.

If we now proceed to evaluate the survival-health status of Curt's red bone marrow, we need to consider whether 0,01 is higher, equal to, or lower than $k_s$. For the sake of simplicity, assume that producing blood cells is the only physiological function of the red bone marrow. Then, if 0,01 is higher than $k_s$, then Curt's red bone marrow is survival-healthy. If 0,01 is not higher than $k_s$ then his red bone marrow is survival-pathological.

I take the value of $k_s$ to be conventional, subject to certain constraints. For example, the value of $k_s$ should at least be smaller than 1. Otherwise there will be pathology without any reduction in efficiency. The value should also be greater than 0. Otherwise, for a trait token to be survival-pathological, it would be required that the further life expectancy of the manipulated CDP is 0. Further, the value of $k_s$ is reasonably closer to 1 than 0. Otherwise, a state would have to reduce further life expectancy to a very large extent for it to count as survival-pathological. We may learn about additional constraints by considering physiological and pathological theory. If we consider the above example, the value of $k_s$ should at least be closer to 1 than 0,01, and hence Curt's red bone marrow is survival-pathological.

I have now accounted for the DPE-theory. We have seen that the account of efficiency solves all three problems with Hausman's account. First, by measuring survival by further life expectancy, it takes into account the likelihoods to survive for all different time intervals. Second,

given the explication of manipulation, it is clear what it means to compare two dispositions as alternative parts of one and the same organism. Third, since the measure of survival-efficiency orders survival-efficiencies on a ratio scale, we can make all relevant efficiency comparisons. We may measure how much the efficiency of one disposition differs from another, where "how much" is not merely statistically described. Also, since the survival-efficiency expresses how beneficial for survival a disposition is in relation to the standard, we can make relevant comparisons between the survival-efficiencies of tokens of different trait types.

By allowing for more relevant efficiency comparisons than Hausman's theory, the DPE-theory may be regarded as more of a complete solution to the problem of common diseases. Hausman's theory avoids this problem, but this is at the cost of not being able to account for a general distinguishing line, or for more or less pathology in comparison to the standard.

## V. KINGMA'S DILEMMA

Let us lastly consider a much discussed objection raised against naturalistic theories of pathology, "Kingma's dilemma" [Kingma (2010)]. Hausman (2011) argues that this objection is no genuine dilemma. However, Kingma (2016) does not accept Hausman's solution.[3] Using the resources of the DPE-theory, I will show that Kingma's answer to Hausman is mistaken, and hence that Kingma's objection is no problem for theories like Boorse's, Hausman's, and the DPE-theory.

Let us first consider the alleged dilemma. Kingma (2010) points out that in order to account for adequate variations in how physiological functions are performed, performances must be considered relative to situations. To see this by an example, consider the following three cases about Carol's digestive system, originally from Kingma (2010), pp. 251-252. In the first case, Carol relaxes after a meal and her digestive system digests at full capacity. In the second case, Carol has fasted and her digestive system is virtually dormant. In the third case, Carol is exercising and her digestive system is virtually dormant. In all of these cases, what the digestive system does is both typical for the situation and considered healthy. Note here that the DPE-theory, with its model of dispositions (SDPs), captures the situation-specificity of physiological functions very well.

However, Kingma (2010), pp. 250-251, argues, if "healthy performances" are relative to what is typical for tokens of a trait type to do in

specific situations, then situation-specific diseases cannot count as patho-
logical. To illustrate her point, Kingma adds a fourth case about Carol's di-
gestive system, where Carol has ingested a poison that paralyzes her
digestive system (and she is relaxing after a meal). Here Carol's digestive
system is virtually dormant. This is a typical response for digestive systems
to such situations. However, intuitively this is a case of pathology. Kingma
thereby concludes that naturalistic theories cannot account both for the sit-
uation-specificity of physiological functions and situation-specific diseases.

According to Hausman (2011), Kingma is mistaken in her formula-
tion of the dilemma. He writes: "Whether it is normal for a part to acquire
some capacity or incapacity in some situation S is a different question from
whether the capacity or incapacity it acquires in S is normal" [Hausman
(2011), p. 664]. What is relevant for health, he points out, is the latter. I
think that Hausman is correct here. Expressed in terms of the DPE-
theory, a trait token is survival-healthy if and only if its SDPs meet the sur-
vival-exemplary CDP's corresponding SDPs (well enough). Assume that
before the poison harms Carol's digestive system, its SDP for digestion is
like the survival-exemplary CDP's SDP for digestion. But after the harm is
made, Carol's digestive system's SDP for digestion is different from that of
the survival-exemplary CDP, perhaps by reporting of no activity in the sit-
uation of resting after a meal. Whether it would be typical for members of
the reference class to get their SDPs affected when in the situation of the
trait token under evaluation does not matter. Since most reference class
members have not ingested the poison which Carol has, it is not typical to
have an SDP for digestion like Carol´s. And since Carol's SDP for diges-
tion gives a lower further life expectancy than that of the survival-
exemplary CDP, its survival-efficiency is reduced. If it is significantly re-
duced, then Carol's digestive system is survival-pathological.

Kingma argues that Hausman's (2011) response is inadequate, since
it fails to generalize [(2016), p. 392]. Kingma argues this by several ex-
amples. Since these examples are all pressing the same point, it suffices
to consider one of them:

> Take, for example, a healthy pregnant woman–that is, a woman who per-
> forms statistically typical functions for being at the stage of pregnancy that
> she is in. According to Hausman, the normal dispositional function of
> such a person should be compared to that of the population or reference
> class as a whole rather than, on Kingma's (2010) interpretation, to that of
> other pregnant women. That commits Hausman to recognizing a slew of
> pregnancy-related pathologies: amongst many others, pregnant women–in
> comparison to the whole population–have a reduced ability to run, lift, or

bend over; are more disposed to sustain joint injuries because hormonal changes make soft tissue more flexible; have some suppression of the immune system; are less able to store moderate quantities of urine in their bladder; and lack various other normal physical abilities, such as the ability to directly come up to a sitting position from a position of lying on one's back, or the ability to keep sufficient tension in one's pelvic floor whilst sneezing or coughing. Against Hausman, however, none of these problems are medically or conventionally considered pathologies; they are considered a normal aspect of being pregnant [Kingma (2016), p. 395].

When we evaluate the health status of some particular trait token of a pregnant woman, we should compare this trait token's dispositional function against the whole reference class, rather than merely against other pregnant members of the reference class. Importantly, though, this does not imply that normal conditions of pregnancy are pathological. Kingma's mistake here is to claim that a healthy pregnant woman has different dispositional functions compared to other non-pregnant women in the same reference class simply by being pregnant. Although the pregnant woman presently has a reduced ability to run, lift, bend over, and so on, a non-pregnant woman is disposed to have the same difficulties in a situation of being pregnant. To be clear, what Kingma misses to take into consideration is that the situation includes facts such that there is a fetus in the uterus, and that certain hormones are at certain levels.

Considering the DPE-theory, this should be clear. In a trait token's SDP, every performance is relative to a situation, where the situation includes facts both internal and external to the organism. To see that internal facts (such as having certain hormone levels) cannot be excluded from the situation, remember that an account of pathology must be able to account for the situation-specificity of physiological functions. For many physiological functions, what is an adequate performance varies with internal facts. For example, the presence of food within one's mouth makes it adequate for the salivary glands to produce saliva, and the presence of food within one's stomach makes it adequate for certain cells in the stomach to release gastrin, and the presence of gastrin in turn makes it adequate for certain other cells in the stomach to release hydrochloride acid. Also if we look at Kingma's own example, it should be clear that the situation must include internal facts. In order to account for the health of a suppressed immune system in cases of pregnancy, the immune system's reactivity must be relativized to internal facts, such that there is a fetus in the uterus, or that certain hormones are at a certain level.

By the DPE-theory's explication of dispositions, it should be clear that Kingma's dilemma is no genuine dilemma for naturalistic theories of pathology.


## VI. CONCLUSION

This paper has presented the DPE-theory, which accounts for efficiency and its connection to health status evaluations. The suggested definition of 'efficiency' is more precise than Boorse's notion of efficiency, and it does not have the problems of Hausman's definition. We have also seen that the DPE-theory contributes to showing that Kingma's dilemma is no genuine dilemma for naturalistic theories of pathology. Of course, there are still parts of the DPE-theory that prompts further investigation, but I hope to have shown that the DPE-theory constitutes a promising naturalistic account of pathology.

My primary purpose in this paper has been to develop a theoretically sound theory. We may, however, observe that the DPE-theory seems somewhat difficult to apply in practice. It will be difficult to calculate the exact survival-efficiencies of different dispositions, since it is hard to determine exact further life expectancies of different CDPs. It may still be possible, however, to do rough estimations of further life expectancies. Given that these estimations are accurate enough, the DPE-theory is practically applicable.[4]

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NOTES

[1] If there are other relevant goals to consider besides survival and reproduction, it should be possible to develop additional efficiency and pathology concepts based on these goals.
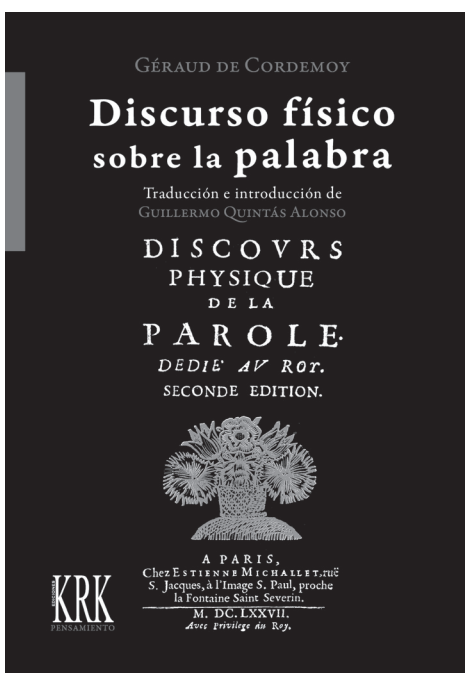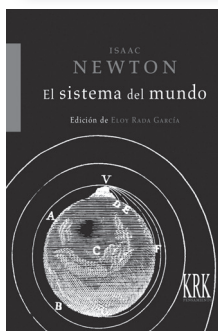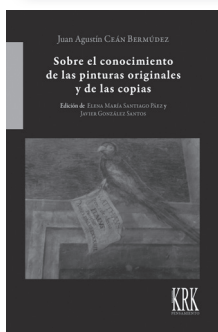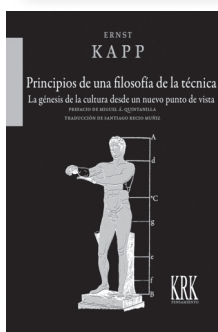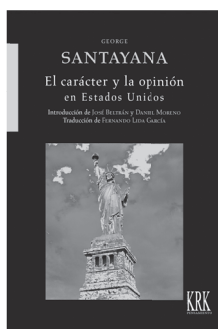
[2] It should, however, be possible to develop a comparative account similar to the one I suggest.

[3] Boorse (2014), pp. 704-705, and Garson and Piccinini (2014), pp. 14-18, argue in the same way as Hausman that Kingma's objection is no genuine dilemma. However, Kingma (2016) only discusses Hausman's (2011) response.

⁴ Here we may make a parallel to utilitarianism, where an action is morally right if and only if it maximizes utility. That it is practically difficult for us to determine the utility of different possible actions does not mean that utilitarianism is not a useful theory. It offers an explanation of moral rightness, and although we cannot completely reliably determine the exact utility of different possible actions, we can make qualified estimations.

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