

# Malfunctioning Artifacts: A Step Towards a Realizable-Centered Unifying Account

Fumiaki Toyoshima<sup>1,\*</sup>, Ludger Jansen<sup>2,3</sup>

<sup>1</sup>*Institut de philosophie, Faculté des lettres et sciences humaines, Université de Neuchâtel, Espace Tilo-Frey 1, 2000 Neuchâtel, Switzerland*

<sup>2</sup>*PTH Brixen College, Piazza di Seminario 4, 39042 Bressanone, Italy*

<sup>3</sup>*Universität Rostock, Institute for Philosophy, 18051 Rostock, Germany*

## Abstract

Malfunctioning artifacts remain elusive from an ontological point of view, not least owing to the complexity of both notions of function and artifact. This paper aims to take the initial steps towards a unifying account of malfunctioning artifacts that centers around the notion of realizable entity. We begin by examining some major distinctions between theories of artifactual functions (e.g., intention-based and realizable-centered). Based on this examination, we propose to provide an ontological account of the malfunctioning of artifacts by drawing on a “realizable-centered approach to artifacts” which is recently proposed in formal ontology. The pivotal idea of this account is that an artifact is malfunctioning when some relevant “intentional realizable entity” thereof is not realized.

## Keywords

malfunctioning, artifact, realizable entity, function, intention

## 1. Introduction

Malfunctioning is pervasive. It figures both in the natural world (e.g., the hyperfunctioning of the heart) and in the artifactual world (e.g., the meltdown of a nuclear reactor). It is nonetheless notoriously difficult to analyze the notion of malfunctioning from an ontological viewpoint. This is not least because the term “malfunctioning” has been very differently used in different domains and, more fundamentally, because there is no broad agreement about what functions are to be ontologically analyzed.

This paper aims to sketch a general theoretical framework for understanding the malfunctioning of artifacts that is founded on the ontology of realizable entities. A realizable entity is a property that can be realized in associated processes of a specific correlated type in which the bearer participates – a conceptual view of realizable entities (e.g., [1]) being left aside. For example, dispositions are a paradigmatic kind of realizable entities: the fragility of a glass can be analyzed as a disposition whose bearer is this glass and which can be realized in a process of the glass breaking when the glass is pressed with sufficient force. While the upper ontology Basic Formal Ontology (BFO) [2, 3, 4] features the category of realizable entity, we will focus on a notion of realizable entity that is general enough to be adaptable to other foundational ontological frameworks and as broad as the notion of disposition in McKittrick’s [5] “dispositional pluralism” (see [6] for details) – including in particular so-called extrinsic dispositions, i.e., causal properties that are not grounded in intrinsic physical properties alone.. For example, the category of disposition in the Unified Foundational Ontology (UFO) [7, 8] can also be understood as a kind of realizable entity.

In particular, we will consider the malfunctioning of artifacts by leveraging a “realizable-centered approach to artifacts” [9, 10, 11]. This approach has been put forward as an alternative to the traditional intention- or function-based accounts of artifacts, so as to theoretically underpin a formal ontology

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\*Corresponding author.

✉ fumiaki.toyoshima@unine.ch (F. Toyoshima); ludger.jansen@pthsta.it (L. Jansen)

🌐 <https://jansenludger.github.io/home/> (L. Jansen)

🆔 0000-0002-4690-1221 (F. Toyoshima); 0000-0002-0097-6359 (L. Jansen)



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of artifacts in general, ranging widely from technical artifacts (e.g., screwdrivers) to artworks (e.g., ready-mades) and spiritual artifacts (e.g., amulets). It can be therefore expected to serve as a point of reference from which to compare existing different accounts of the malfunctioning of artifacts that are based on different conceptions of functions.

The paper is organized as follows. Section 2 spells out some important distinctions between theories of artifactual functions (e.g., intention-based and realizable-centered) and introduces some basic notions (e.g., intrinsic and extrinsic dispositions) used in a realizable-centered approach to artifacts. Section 3 proposes an ontological analysis of the malfunctioning of artifacts by deploying the existing realizable-centered analysis of artifacts. Section 4 briefly discusses related work. Section 5 concludes the paper. Note that we will write terms for types and particulars in italics and bold, respectively (e.g., *Screwdriver* and **pebble<sub>1</sub>**).

## 2. The theoretical background

Section 2.1 scrutinizes three prominent distinctions between theories of artifactual functions with a focus on malfunctioning artifacts: particular-oriented and type-oriented (Section 2.1.1), intention-based and realizable-centered (Section 2.1.2) and disposition-grounded and disposition-free (Section 2.1.3). This will specify the scope of our investigation in this paper and motivate the application of a realizable-centered approach to artifacts (Section 2.2) to understanding the malfunctioning of artifacts.

### 2.1. Theories of artifactual functions

#### 2.1.1. Particular-oriented and type-oriented

Talk of artifactual functions is frequently coupled with talk of domain-specific artifact types, e.g., the type *Screwdriver* in the common statement: “This screwdriver is malfunctioning, as it is incapable of turning screws”. For example, Jespersen & Carrara [12, 13] argue for two interpretations (“subsective” and “privative”, which will be explained in more detail shortly) of the malfunctioning of technical artifacts, based on the notion of “malfunctioning *F*” – where *F* refers to “a technical-artefact property” (ibid., p. 118), or more generally, a domain-specific artifact kind in our preferred terms.

In contrast with such “type-oriented” theory of artifactual functions, for instance, Baker [14, p. 85] provides a “particular-oriented” view of the malfunctioning of artifacts as follows:

- (M) *x* is a malfunction of an artefact *a* if and only if:
- (a) *x* is a failure to perform the intended function of *a*, where the intended function of *a* is such that it is physically possible to be performed, and
  - (b) *x* occurs when a competent operator tries to use *a* to perform its intended function under conditions for which *a* was designed.

Note that Baker uses italicized letters as individual variables, whereas we use letters in boldface as individual constants. According to Baker’s formulation (M), it is a particular artifact (“*a*”) that is said to malfunction or not.

In this paper we will adopt a particular-oriented theory of artifactual functions. For one thing, domain-specific artifact kinds may be certainly crucial to account for *function ascriptions*, i.e., roughly, for sentences or propositions that describe the entities and phenomena involving functions. However, the type-oriented theory of artifactual functions may not serve to theoretically underwrite a general ontology of *functions* and (mal)functioning as clearly as the particular-oriented theory can, because dealing with domain-specific artifact kinds may need careful ontological consideration.

To illuminate this point, consider Jespersen & Carrara’s [12, 13] two interpretations of the malfunctioning of technical artifacts: subsective and privative. The subsective interpretation says that malfunctioning *F*s are *F*s, whereas the privative interpretation says that malfunctioning *F*s are not *F*s. Arguably, it depends at least partially (or even largely) on the definition of a given domain-specific artifact-kind term whether the subsective or privative interpretation is to be adopted. For example,

it will require defining (or at least elucidating) the term “smartphone” whether a particular malfunctioning smartphone is still a smartphone or not – for example, when it fails to facilitate remote vocal communication, which will, in turn, require considering, e.g., whether *Smart“phone”* is a subtype of *Telephone* or not.

### 2.1.2. Intention-based and realizable-centered

Artifactual functions are typically characterized in terms of intentions. Moreover, as artifacts (especially technical artifacts) are typically characterized in terms of functions, they are typically characterized in terms of intentions. Intentions, functions and artifacts are generally assumed to be inextricably linked with one another.

There may be nonetheless some limitations with the intention-based theory of functions as well as the intention- and function-based theory of artifacts, in particular when it comes to an ontological analysis of the malfunctioning of artifacts that can be found outside the engineering domain. To illustrate this point, let us consider the following two scenarios:

- At time  $t$ , this pebble (**pebble<sub>1</sub>**) is intended to be used to dispel evil spirits.
- At time  $t'$ , that pebble (**pebble<sub>2</sub>**) is intended to be used to keep papers in place (regardless of whether it is actually so used or not).

As one (if not the only) prevailing view goes, **pebble<sub>1</sub>** at time  $t$  is an artifact, as it may be thought of as an amulet, and Baker considers an amulet to be “a paradigm case of a technical artefact” [14, p. 84]. By contrast, **pebble<sub>2</sub>** at time  $t'$  is not an artifact and it is rather a natural object to be intended to be used for some purpose – notwithstanding Borgo & Vieu’s [15] noteworthy exceptional view that, at time  $t'$ , a new material entity (say **paperweight<sub>2</sub>**) constituted by **pebble<sub>2</sub>** comes into being and **paperweight<sub>2</sub>** is an artifact (see also [16] and [11] for details on their theory of artifacts and for other possible views of these examples).

Now according to one version of the intention- and function-based theory of artifacts, artifacts are ontologically explicable in terms of “design functions”, rather than in terms of “use functions”. Roughly, design functions are the functions imposed on artifact by their designer(s), and use functions are what users actually use artifacts for, as when a screwdriver is used to open a paint can (see, e.g., [17, 18, 19] for more on design and use functions). Consequently, whether an entity is an artifact or not is determined by whether the entity is intended by the designer, or not (e.g., by the user).

It may be nevertheless contentious whether this version of the intention- and function-based theory of artifacts can well accommodate the prevailing view (currently under consideration) that **pebble<sub>1</sub>** at time  $t$  is an artifact but **pebble<sub>2</sub>** at time  $t'$  is not. This is because it is challenging to articulate clearly the ontological difference between the intention to use **pebble<sub>1</sub>** to dispel evil spirits and the intention to use **pebble<sub>2</sub>** to keep papers in place. Furthermore, given that the term “design” refers to a planning process for production in the engineering domain, it would be all the less clear to think that **pebble<sub>1</sub>** at time  $t$  is intended by the designer but **pebble<sub>2</sub>** at time  $t'$  is by the potential user, because using **pebble<sub>1</sub>** to dispel evil spirits is nomologically impossible in light of (our knowledge of) the laws of nature in our actual world, but using **pebble<sub>2</sub>** to keep papers in place is nomologically possible (cf. [11] for a critical examination of the notion of design in the ontology of artifacts).

All these considerations can motivate exploring artifactual functions and artifacts differently from the intention-based theory of functions as well as the intention- and function-based theory of artifacts. One possible alternative approach is a realizable-centered approach to artifacts [9, 10, 11], which will be detailed in Sections 2.2 and 3.

### 2.1.3. Disposition-grounded and disposition-free

The realizable-centered approach is naturally combined with the supposition that (artifactual) functions are a kind of realizable entities [10]. In effect, there is broad consensus within the BFO-relevant research that *Function* should be a subtype of BFO:*Realizable entity*, rather than BFO:*Process* [3, 17, 19].

There is however a long-standing debate over the status of functions within the BFO category of realizable entity. According to the latest, ISO-standard version of BFO (ISO/IEC 21838-2), *Function* is a subtype of BFO:*Disposition* [3] (note that we will employ the term “BFO:*Function*” to refer to *Function* as construed by BFO in this way). In more detail, a disposition in BFO is a realizable entity that exists because of certain features of the physical makeup of the BFO-independent continuant that is its bearer. It is an “internally grounded realizable entity”: if a BFO:disposition ceases to exist, then the physical makeup of the bearer is changed. Examples include the fragility of a glass and the flammability of a match. A function in BFO is a BFO:disposition of a bearer with a specific kind of historical development. It is a BFO:disposition that its bearer possesses in virtue of its having a certain physical makeup because of how it came into being, either through evolution (when the bearer is a natural biological entity) or intentional design (when the bearer is an artifact). Examples include the function of the heart to pump blood through the body and the function of a screwdriver to turn screws.

It has been objected however that *Function* should not be a subtype of BFO:*Disposition* but rather a subtype of BFO:*Realizable entity*, as distinct from both BFO:*Disposition* and BFO:*Role* [17, 16]. Note that a role in BFO is a realizable entity that (1) exists because the bearer is in some special physical, social, or institutional set of circumstances in which the bearer does not have to be (optionality), and (2) is not such that, if this realizable entity ceases to exist, then the physical make-up of the bearer is thereby changed (external grounding) – examples being the role of being a student and the role by a stone of marking a boundary. There is also the opinion that BFO could embrace a pluralist conception of functions: some functions are BFO:dispositions and other functions are BFO:realizable entities that are neither BFO:dispositions nor BFO:roles (and/or other functions are BFO:roles) [19, 20].

Quite importantly, this debate concerns whether the BFO dispositional theory of functions (i.e., BFO:*Function*) can account for the phenomenon of malfunctioning, because malfunctioning may be well analyzed in terms of the lack of a corresponding BFO:disposition and this conception of malfunctioning would imply that functions exist without relevant BFO:dispositions, hence the categorical independence of *Function* from BFO:*Disposition*. According to Jespersen & Carrara’s [12, 13] (see Section 2.1.1), for instance, both subsective and privative interpretations of the malfunctioning of technical artifacts agree that a malfunctioning *F* lacks the dispositional property of functioning as an *F*.

For another example, Jansen [16, p. 124] distinguishes between “having a malfunction” and “being malfunctioning” and characterizes them as follows:

- A material object *x* has a *malfunction* at *t* with respect to the function to F-in-situation-S, if and only if *x* has the function to F-in-situation-S but *would* not F in S, because, at *t*, it does not have the disposition to F-in-situation-S.
- A material object *x* is *malfunctioning* at *t* with respect to the function to F-in-a-situation-S, if and only if, at *t*, *x* is in situation S but does not F.

On the background of these definitions, a car with a fuel-soaked ignition plug has a malfunction even if nobody wants to drive it, as it would not start when one would try to do so. It is actually malfunctioning if one tries to start it but does not accomplish to do so because of the fuel-soaked ignition plug. Based on this analysis of the notions of malfunction and malfunctioning, BFO:*Function* would make malfunction(ing) conceptually impossible. For if all functions to do something are identical with the disposition to do so, the car would lose its function to drive once it loses its disposition. If malfunctioning requires the presence of a function and the absence of the respective disposition, this can, according to the BFO account, never be the case, as the absence of the disposition would imply that the function is absent as well. And it is no way out to say that the oil-drop only masked the disposition of the car because there was in fact an intrinsic physical change that destroyed the disposition. If the car is chained to a massive piece of concrete, its intrinsic properties remain the same, and hence also, according to BFO, its dispositions. But no car has, of course, the function to-drive-in-spite-of-being-chained-to-massive-concrete-blocks.

To generalize, there are two types of realizable-based theories of artifactual functions which we will call the “disposition-grounded” and “disposition-free”. On the one hand, both theories of artifactual

functions share the view that *Function* is a subtype of *Realizable entity*. On the other hand, the disposition-grounded theory (as illustrated by BFO:*Function*) says that functions depend (existentially) on some relevant disposition(s), or that functions are even a subtype of dispositions, whereas the disposition-free theory counters that functions are (existentially) independent of dispositions. In the following, we will assume the disposition-grounded theory in developing a realizable-centered account of malfunctioning artifacts. For one thing, at least some (if not all) ideas underlying the disposition-free theory may be captured within the framework of the disposition-grounded theory (combined with a realizable-centered approach to artifacts). We will illustrate this point in Section 3.

## 2.2. A realizable-centered approach to artifacts

We will present some basic notions used in a realizable-centered approach to artifacts [9, 10, 11]. Within the McKittrick-inspired ontology of realizable entities (see Section 1), there are two important, contrasting kinds of realizable entities: intrinsic dispositions and extrinsic dispositions. An intrinsic disposition is a realizable entity that is borne purely in virtue of the way the bearer is, for example, in virtue of the internal (physical) structure of the bearer. Classical examples include the intrinsic disposition of fragility. As the term “disposition” traditionally refers to an intrinsic disposition, disposition-grounded and disposition-free theories of artifactual functions may be understood (primarily) as the issue of whether artifactual functions are grounded in some intrinsic disposition(s) or not (see Section 2.1.3).

An extrinsic disposition is a realizable entity that is borne, at least partially, in virtue of the way the world that is external to the bearer is (see [5, 6] for careful analysis). Classical examples include the extrinsic disposition  $d_{\text{key}_a}$  of a particular key ( $\text{key}_a$ ) to open a *particular* lock ( $\text{lock}_b$ ). In more detail: when  $\text{lock}_b$  is annihilated and ceases to exist, then  $d_{\text{key}_a}$  ceases to exist even without any physical changes of  $\text{key}_a$ , because  $\text{key}_a$  bears  $d_{\text{key}_a}$  in virtue of the existence of  $\text{lock}_b$ , which is external to  $\text{key}_a$ .

While it is a standard research question in the ontology of artifacts what is the correct (and ideally single) definition of the existing term “artifact”, this approach adopts the different methodology of investigating the two newly introduced notions, *canonical artifact* and *usefact*, which help to understand very different usages of the term “artifact” in different domains.

A canonical artifact is something that is intentionally produced for some purpose. The notion of canonical artifact corresponds to the traditional account of artifacts in philosophy of artifacts (e.g., [28]), hence the term “*canonical artifact*”. For illustration, when I intentionally shaped and dried a certain amount of clay in such a way as to be able to contain liquid, the resulting clay pot is a canonical artifact because it is intentionally produced for the purpose of being able to contain liquid. As we will discuss in Section 4,  $\text{pebble}_1$  at time  $t$  can be seen as a kind of canonical artifact whose intentional and “production” dimensions merit special treatment (see [11] for detailed analysis).

In contrast, a usefact is something that is intended to be used for some “accidental purpose”, which means (without recourse to the complex distinction between essentiality and accidentality) some purpose that is different from the purpose (if any) for which the entity was intentionally produced. In particular, a natural object is a usefact when it is intended to be used for any purpose, because it was not intentionally produced for any purposes (or this is an assumption that we make in understanding natural objects). To take an example in Section 2.1.2,  $\text{pebble}_2$  is a usefact at time  $t'$  because it is intended to be used for the accidental purpose of keeping papers in place, or particularly, for the trivial reason that it is a natural object that is intended to be used for some purpose. Concerning the usage of the notion of usefact, Borgo & Vieu’s [15] formal theory of artifacts is a case in point, as their term “artifact” can be construed as referring to usefacts as well as canonical artifacts (see Section 2.1.2).

## 3. A realizable-centered analysis of malfunctioning artifacts

After explaining the basic idea of the malfunctioning of artifacts (Section 3.1), we will investigate, by analyzing examples based on the ontology of realizable entities, the malfunctioning of material artifacts when the term “material artifact” refers to material canonical artifacts (Section 3.2) and material usefacts

(Section 3.3). To recall, we will assume a theory of artifactual functions that is particular-oriented, realizable-centered and disposition-grounded (see Section 2.1).

### 3.1. Malfunctioning artifacts: A basic idea

There are so many accounts of malfunctioning in the literature that it is difficult to give even a general overview (see, e.g., [21, 22] for a general survey). Following e.g., Artiga [20], we will presuppose the following general characterization of the malfunctioning of artifacts:

**Proposition 1** (the malfunctioning of material artifacts)

A material artifact is malfunctioning if and only if (i) it has some function and (ii) it does not perform this function in the way it is supposed to.

Some clarifications on Proposition 1 are in order. Firstly, Proposition 1 is about the malfunctioning of *material* artifacts. By focusing on this proposition, we will leave aside the potentially highly complex issue of the malfunctioning of abstract artifacts, including that of softwares [23] and fictional characters [24]. Moreover, we are mainly interested in the malfunctioning of *particular* material artifacts, as we assume a particular-oriented theory of artifactual functions (see Section 2.1.1).

Secondly, terms such as “(material) artifact”, “have a function” and “perform a function” figuring in Proposition 1 are intended to be neutral as to which theories of artifacts and/or functions are adopted. In what follows we will interpret this proposition based on a realizable-centered and disposition-grounded theory of artifactual function, according to which functions are a kind of realizable entities that are grounded in some relevant disposition(s) (see Sections 2.1.2 and 2.1.3).

Thirdly, we will use, whenever possible, the verb phrase “to be malfunctioning” in discussing the malfunctioning of artifacts. For one thing, we want to remain agnostic as to the meanings of other malfunctioning-related terms, including “failure” and “fault” [25, 26] as well as “dysfunction” [27], which are frequently used in engineering and in biology, respectively. For another, we avoid using the noun “malfunction” and the simple tense of the verb “to malfunction” because they could yield terminological confusion in view of the distinction between “malfunction” and “malfunctioning” (as advocated by Jansen [16]; see Section 2.1.3).

Fourthly and finally, the malfunctioning of artifacts has some normative dimension, as is shown by item (ii) of Proposition 1 (“in the way it is *supposed* to”) and is explicitly highlighted by Baker [14]. At the same time, Proposition 1 is neutral as to the source of the normativity of the malfunctioning of artifacts. In the ensuing we will analyze the normativity in question by utilizing a realizable-centered approach to artifacts, to wit, in terms of a special kind of realizable entity (“intentional realizable entity”; see Section 3.2) involving a relevant intentional dimension.

### 3.2. The malfunctioning of material canonical artifacts

For sake of simplicity, the following discussion will presuppose the “continuity view” of diachronic identity with respect to production (see [9, 10, 11] for details). Under this view, a material canonical artifact is not a new material entity (e.g., **pot**<sub>1</sub>) that comes into being at a certain time (which is the case with the “non-continuity view” of production), but a pre-existing material entity that comes to instantiate a relevant class (e.g., **clay**<sub>1</sub> instantiating *Pot*) at that time. We emphasize that, although the non-continuity view of production may be typically (and often implicitly) adopted in the ontology of artifacts, the continuity view of production can be equally useful in analyzing the malfunctioning of material canonical artifacts.

**Example 1** (material canonical artifact)

At time  $t_1$ , a particular amount of clay (**clay**<sub>1</sub>) was shaped and dried to be able to contain liquid.

We will focus on the intrinsic disposition  $\mathbf{d}_1$  to contain liquid that  $\mathbf{clay}_1$  comes to bear at time  $t_1$  purely in virtue of its specific physical (e.g., container-like) structure. According to Toyoshima et al. [9, 10, 11],  $\mathbf{clay}_1$  is a material canonical artifact in virtue of bearing  $\mathbf{d}_1$  because  $\mathbf{d}_1$  is an intentional realizable entity and it is also a novel realizable entity, these two kinds of realizable entities being defined as follows [11]:

**Definition 1** (intentional realizable entity)

intentional realizable entity =<sub>def.</sub> A realizable entity (i) that comes into being through an intentional act and (ii) whose realization is determined by an associated goal.

**Definition 2** (novel realizable entity)

novel realizable entity =<sub>def.</sub> A realizable entity  $r$  such that the bearer has no realizable entity  $r'$  such that (i)  $r'$  exists before  $r$  came into being and (ii) if  $r$  is realized in a process, then  $r'$  is realized in the same process.

First,  $\mathbf{d}_1$  is an intentional realizable entity, as it comes into being the intentional act of shaping and drying  $\mathbf{clay}_1$  and its realization (i.e., a process of  $\mathbf{clay}_1$  containing liquid) is determined by the goal that  $\mathbf{clay}_1$  should contain liquid.<sup>1</sup> Second,  $\mathbf{d}_1$  is a novel realizable entity, as there is no pre-existing realizable entity  $r'$  of  $\mathbf{clay}_1$  such that, if  $\mathbf{d}_1$  is realized in a process of  $\mathbf{clay}_1$  containing liquid, then  $r'$  is also realized in this process.

Toyoshima et al. [9, 10, 11] define the term “material canonical artifact” in terms of intentional and novel realizable entities as follows:

**Definition 3** (novel intentional realizable entity)

novel intentional realizable entity =<sub>def.</sub> An intentional realizable entity that is a novel realizable entity.

**Definition 4** (material canonical artifact)

material canonical artifact =<sub>def.</sub> A material entity that bears a novel intentional realizable entity.

According to these definitions,  $\mathbf{d}_1$  is a novel intentional realizable entity and  $\mathbf{clay}_1$  is a material canonical artifact at time  $t_1$ .

Let us now investigate the malfunctioning of material canonical artifacts by considering the following example:

**Example 2** (the malfunctioning of material canonical artifacts)

At time  $t_2$  (later than  $t_1$ ),  $\mathbf{clay}_1$  is intended to be used to, but fails to, contain a particular amount of liquid ( $\mathbf{liquid}_2$ ).

For expository purposes, we will first consider the normative dimension of the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$  (item (ii) of Proposition 1). Arguably, the normativity under question stems from the fact that  $\mathbf{clay}_1$  is intended to be used to contain  $\mathbf{liquid}_2$  at time  $t_2$ , or more specifically, from the intention to use  $\mathbf{clay}_1$  to contain  $\mathbf{liquid}_2$  at time  $t_2$  ([29]; see Section 4). One realizable-based way of interpreting the claim is to think that, at time  $t_2$ ,  $\mathbf{clay}_1$  comes to bear an extrinsic disposition  $\mathbf{d}_2$  to contain  $\mathbf{liquid}_2$  such that  $\mathbf{d}_2$  exists in virtue of the existence of the intention to use  $\mathbf{clay}_1$  for that purpose at time  $t_2$ . Note that  $\mathbf{d}_2$  is an intentional realizable entity, as it comes into being through the intentional act using  $\mathbf{clay}_1$  to contain liquid and its realization is determined by the goal of  $\mathbf{clay}_1$  containing liquid. We propose to understand the normativity of the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$  in terms of the intentional realizable entity  $\mathbf{d}_2$ .

We will next consider a function that is involved in the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$  (item (i) of Proposition 1) or more specifically which realizable entity of  $\mathbf{clay}_1$  is a relevant function at time  $t_2$  (according to a realizable-centered theory of artifactual functions). There are at least two realizable entities that can be a function relating to the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$ .

<sup>1</sup>See [11] for details on mental entities relevant to the ontology of artifacts, such as intentions and (intentional) goals.

- The intrinsic disposition  $\mathbf{d}_1$  — as it is reasonable to link the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$  with the realization of  $\mathbf{d}_1$ , i.e., a process of  $\mathbf{clay}_1$  containing liquid.
- The extrinsic disposition ( $\mathbf{d}_{\mathbf{liquid}2}$ ) to contain  $\mathbf{liquid}_2$  — such that  $\mathbf{clay}_1$  comes to bear  $\mathbf{d}_{\mathbf{liquid}2}$  at time  $t_1$  partly in virtue of the existence of  $\mathbf{liquid}_2$ , which is external to  $\mathbf{clay}_1$  (assuming that  $\mathbf{liquid}_2$  exist at time  $t_1$ ).<sup>2</sup>

We highlight that  $\mathbf{d}_{\mathbf{liquid}2}$  is intimately connected with but different from the intrinsic disposition  $\mathbf{d}_1$ , as  $\mathbf{d}_1$  can be realized in a process of  $\mathbf{clay}_1$  containing any instance (e.g.,  $\mathbf{liquid}_2$ ) of the type *Liquid*, whereas  $\mathbf{d}_{\mathbf{liquid}2}$  can be realized in a process of  $\mathbf{clay}_1$  containing  $\mathbf{liquid}_2$ . Moreover,  $\mathbf{clay}_1$  is a material canonical artifact at time  $t_2$  (as well as at time  $t_1$ ) in virtue of bearing  $\mathbf{d}_{\mathbf{liquid}2}$  because, just as with  $\mathbf{d}_1$ ,  $\mathbf{d}_{\mathbf{liquid}2}$  is a novel intentional realizable entity.

We can thus specify three possible interpretations of Example 1 depending on whether  $\mathbf{d}_1$  is a function or not and whether  $\mathbf{d}_{\mathbf{liquid}2}$  is a function or not, while excluding the possibility that neither  $\mathbf{d}_1$  nor  $\mathbf{d}_{\mathbf{liquid}2}$  is a function:

- Interpretation 1:  $\mathbf{d}_1$  is a function and  $\mathbf{d}_{\mathbf{liquid}2}$  is also a function.
- Interpretation 2:  $\mathbf{d}_1$  is a function but  $\mathbf{d}_{\mathbf{liquid}2}$  is not a function.
- Interpretation 3:  $\mathbf{d}_1$  is not a function but  $\mathbf{d}_{\mathbf{liquid}2}$  is a function.

We underscore that Interpretations 1 and 3 may help to understand some ideas behind the disposition-free theory of artifactual functions in the present context of the disposition-grounded theory (see Section 2.1.3). According to these two interpretations,  $\mathbf{d}_{\mathbf{liquid}2}$  is a function. Since  $\mathbf{d}_{\mathbf{liquid}2}$  is an extrinsic disposition, these interpretations allow for the possibility that some extrinsic dispositions can be functions. To be sure, functions that are extrinsic dispositions may not be disposition-free functions, as they depend (existentially) on some intrinsic disposition(s) [6]. However, they are not intrinsic dispositions either and, for example, they are not BFO: *functions* (see Section 2.1.3), provided that the BFO notion of being an internally (respectively: externally) grounded realizable entity corresponds approximately to our notion of being an intrinsic (respectively: extrinsic) disposition [6, 19]. In this respect, functions that are extrinsic dispositions — e.g.,  $\mathbf{d}_{\mathbf{liquid}2}$  under Interpretation 1 or 3 — may be seen as “surrogates for disposition-free functions” within the scope of the disposition-grounded theory.

We will now analyze the case in which  $\mathbf{d}_1$  is a function (Interpretations 1 and 2) and the case in which  $\mathbf{d}_{\mathbf{liquid}2}$  is a function (Interpretations 1 and 3). For this purpose, we will introduce the relation of “being non-novel because of” between realizable entities [11]:

**Definition 5** (is non-novel because of)

A realizable entity  $r$  is non-novel because of a realizable entity  $r' =_{\text{def.}}$

There exists some bearer  $b$  such that (i)  $b$  bears  $r$  and (ii)  $b$  bears  $r'$  and (iii)  $r'$  exists before  $r$  comes into being and (iv) if  $r$  is realized in a process, then  $r'$  is realized in the same process.

In the first case,  $\mathbf{clay}_1$  is malfunctioning with respect to  $\mathbf{d}_1$ , and thus  $\mathbf{d}_1$  is not realized, at time  $t_2$ . Now recall that  $\mathbf{d}_2$  can be helpful in analyzing the normativity of the malfunctioning of  $\mathbf{clay}_1$  at time  $t_2$ . We can apply the relation specified by Definition 5 to the analysis of the connection between  $\mathbf{d}_1$  and  $\mathbf{d}_2$  in such a way that  $\mathbf{d}_2$  is non-novel because of  $\mathbf{d}_1$  (informally: the canonical artifact  $\mathbf{clay}_1$  is intended to be used for the same purpose for which it was intentionally produced). One consequence of this analysis is that, since  $\mathbf{d}_1$  is not realized,  $\mathbf{d}_2$  is not either, according to Definition 5. This analysis can apply, *mutatis mutandis*, to the second case, where  $\mathbf{clay}_1$  is malfunctioning with respect to  $\mathbf{d}_{\mathbf{liquid}2}$ . That is to say,  $\mathbf{d}_{\mathbf{liquid}2}$  is not realized and  $\mathbf{d}_2$  is non-novel because of  $\mathbf{d}_{\mathbf{liquid}2}$ .

We can generalize these observations as to  $\mathbf{d}_1$ ,  $\mathbf{d}_{\mathbf{liquid}2}$  and  $\mathbf{d}_2$  into the following realizable-based characterization of the malfunctioning of material canonical artifacts:

<sup>2</sup>We leave out of scope the interpretation that, in contrast with  $\mathbf{d}_{\mathbf{liquid}2}$ ,  $\mathbf{d}_2$  has as (part of) its realization a process of the user’s desire to use  $\mathbf{clay}_1$  to contain  $\mathbf{liquid}_2$  coming to be satisfied. See also [11] for discussion on the issue of the identity of realizable entities.

**Proposition 2** (the malfunctioning of material canonical artifacts and realizable entities)

A material canonical artifact  $a$  is malfunctioning if and only if:

there exist some function  $f$  and some intentional realizable entity  $r$  such that (i)  $a$  bears  $f$  and (ii)  $a$  bears  $r$  and (iii)  $f$  is a novel intentional realizable entity and (iv)  $f$  is not realized and (v)  $r$  is non-novel because of  $f$ .

Informally speaking, Proposition 2 says that a material canonical artifact  $a$  being malfunctioning amounts to the thesis that  $a$  is intended to be used for the same purpose for which it was intentionally produced (ii, iii, v), but  $a$  fails to perform the function  $f$  in the way it is intended to be (i, iv).

### 3.3. The malfunctioning of material usefacts

Let us now turn to investigating the malfunctioning of material usefacts (under the continuity view of use). We will introduce the following example of material usefacts that is parallel to the motivating example of **pebble<sub>2</sub>** at time  $t'$  (introduced in Section 2.1.2):

**Example 3** (material usefact)

At time  $t_3$ , a particular pebble (**pebble<sub>3</sub>**) is intended to be used to keep papers in place (regardless of whether it is actually so used or not).

We will focus on two realizable entities involved in this example. One is the extrinsic disposition **d<sub>3</sub>** to keep papers in place, which **pebble<sub>3</sub>** comes to bear at time  $t_3$  partly in virtue of the existence of the intention to use **pebble<sub>3</sub>** for that purpose. As with **d<sub>2</sub>** (borne by **clay<sub>1</sub>** at time  $t_2$ ) in Example 2, **d<sub>3</sub>** is an intentional realizable entity.

The other is the intrinsic disposition **d<sub>3</sub>\*** to keep papers in place, which **pebble<sub>3</sub>** has borne since before time  $t_3$  purely in virtue of its specific physical (e.g., solid) structure. As compared to **d<sub>1</sub>** (borne by **clay<sub>1</sub>** at times  $t_1$  and  $t_2$ ) in Examples 1 and 2, **d<sub>3</sub>\*** is not an intentional realizable entity and, *a fortiori*, it is not a novel intentional realizable entity, as **pebble<sub>3</sub>** is a natural object and it was not intentionally produced for any purposes — notably, for the purpose of keeping papers in place.

The term “material usefact” is defined in terms of the notions of intentional realizable entity and novel intentional realizable entity (Definitions 1 and 3) as well as the relation of “being non-novel because of” (Definition 5) as follows [9, 10, 11]:

**Definition 6** (material usefact)

material usefact =<sub>def.</sub> A material entity that bears an intentional realizable entity which is non-novel because of some realizable entity that is not a novel intentional realizable entity.

According to this definition, **pebble<sub>3</sub>** is a material usefact at time  $t_3$  because **d<sub>3</sub>** is an intentional realizable entity, **d<sub>3</sub>\*** is not a novel intentional realizable entity and **d<sub>3</sub>** is non-novel because of **d<sub>3</sub>\***. Moreover, we can say that **d<sub>3</sub>** is a “usefactual realizable entity”, this term being defined as follows [10, 11]:

**Definition 7** (usefactual realizable entity)

usefactual realizable entity =<sub>def.</sub> An intentional realizable entity which is non-novel because of some realizable entity that is not a novel intentional realizable entity.

We will now analyze the malfunctioning of material usefacts by considering the following example:

**Example 4** (the malfunctioning of material usefacts)

At time  $t_4$ , **pebble<sub>3</sub>** is intended to be used to, but fails to, keep a paper in place (e.g., owing to a very strong gust of wind).

To consider the malfunctioning of the material usefact **pebble**<sub>3</sub> at time  $t_4$ , we will focus on the extrinsic disposition  $\mathbf{d}_4$  to keep a paper in place that **pebble**<sub>3</sub> comes to bear at time  $t_4$  partly in virtue of the existence of the intention to use **pebble**<sub>3</sub> for that purpose at time  $t_4$ . Regarding the normativity of the malfunctioning of **pebble**<sub>3</sub> at time  $t_4$ , we can understand it in terms of  $\mathbf{d}_4$ , as it is a usefactual realizable entity – in particular,  $\mathbf{d}_4$  is non-novel because of  $\mathbf{d}_3^*$ . Moreover, it is plausible to think that  $\mathbf{d}_4$  is a function that is involved in the malfunctioning of **pebble**<sub>3</sub> at time  $t_4$ .

We can generalize this observation about  $\mathbf{d}_4$  into the following realizable-based characterization of the malfunctioning of material usefacts:

**Proposition 3** (the malfunctioning of material usefacts and realizable entities)

A material usefact  $a$  is malfunctioning if and only if there exist some function  $f$  such that

(i)  $a$  bears  $f$  and (ii)  $f$  is a usefactual realizable entity and (iii)  $f$  is not realized.

To put it informally, Proposition 3 says that a material usefact  $a$  being malfunctioning amounts to the thesis that  $a$  is intended to be used for some accidental purpose (ii), but  $a$  fails to perform the function  $f$  in the way it is intended to be (i, iii).

One important consequence of Proposition 3 is that no material artifact can be malfunctioning if the term “function” therein refers to a usefactual realizable entity that is *being realized*. To illustrate this point, we will introduce the term “usefactual realized entity” that is defined as follows [10, 11]:

**Definition 8** (usefactual realized entity)

usefactual realized entity =<sub>def.</sub> A usefactual realizable entity that is realized.

The notion of usefactual realized entity can be useful in analyzing existing conceptions of functions that are based exclusively on *actual* use (such as “sporadic user-intended function” [18] and “narrow use function” [19]) and, according to Proposition 3 and Definition 8, no usefactual realized entity can be a function that is involved in the malfunctioning of any material usefacts. At the same time, it warrants exploration whether and how Proposition 3 could be extended to cases where, for example, a pebble is so conventionally used to keep papers in place that it might have a use function (to wit, “conventional user-intended function” [18]) to keep papers in place even when there is no paper on my desk and it is not currently intended for that use purpose.

## 4. Discussion of related work

In this section we will discuss some selected works on malfunctioning (of artifacts) in order to elucidate our realizable-centered account of malfunctioning artifacts and to specify possible directions of research in which to further develop our approach.

First of all, our realizable-centered account of malfunctioning artifacts is akin to Roberts’s [29] Dispositional Account of technical Functions (DAF), some of whose core ideas can be presented as follows:

DAF: If  $x$  is a technical function of artifact  $A$ , then  $x$  is ultimately referring to a disposition of  $A$ . [29, p. 7; note that the term “ultimately referring to” therein can be arguably omitted.]

DAF Malfunction: Artifact  $A$  malfunctions only if some appropriate use case  $R$  is carried out and the expected disposition does not manifest. [29, p. 11]

It is straightforward to see that (DAF) and (DAF Malfunction) are comparable to our realizable-centered account of artifactual functions and malfunctioning artifacts, as is witnessed by the intimate connection between (DAF Malfunction) and Proposition 2 (see Section 3.2) – in particular, items (iv) and (v) thereof.

At the same time, there are some important differences between Roberts’s and our accounts of the malfunctioning of artifacts. First, the term “artifact” refers to canonical artifacts for him, whereas it

can refer to usefacts as well for us (Proposition 3; see Section 3.3). Second, he seems to use the term “disposition” to refer (primarily) to an intrinsic disposition, whereas we leave open the possibility of the existence of functions that are extrinsic dispositions, as it may serve as surrogates for disposition-free functions (see Section 3.2).

Third, (DAF Malfunction) implies that “phantom functions are a severe case of malfunctioning” [29, p. 11], where the term “phantom function” was proposed by Preston [30] to refer to a function of a kind of artifact that the artifact is “constitutionally incapable of performing” (ibid., p. 177; see also Krohs’ [27] notion of “type-malfunction”). We can illustrate the notion of phantom function with the motivating example of **pebble<sub>1</sub>** at time *t* (see Section 2.1.2): **pebble<sub>1</sub>** has a phantom function to dispel evil spirits at time *t*.

*Pace* Roberts, we find it problematic to integrate the notion of phantom function into a realizable-centered theory of artifactual functions because it would be committed to the highly controversial thesis that there are some realizable entities whose realizations are nomologically impossible (but see [31] for a dissenting voice). A different interpretation of the **pebble<sub>1</sub>** at time *t* scenario can be derived from Baker’s [14] account of malfunctioning artifacts (see Section 2.1.1). According to this interpretation, **pebble<sub>1</sub>** at time *t* has the intended function to dispel evil spirits, but it cannot malfunction because it is physically impossible to perform this intended function.

In contrast with Roberts’s and Baker’s function-based accounts of artifacts, our realizable-centered account of artifacts and their malfunctioning can offer a third view of **pebble<sub>1</sub>** at time *t* by deploying Koslicki & Massin’s [32] analysis of “faith-based artifacts” in terms of what they call “placebo capacities”. According to their explanation, a faith-based artifact is an artifact of a kind that is intended and believed by its creators and users to perform a function which it does not in fact perform. Examples of faith-based artifacts include amulets such as **pebble<sub>1</sub>** at time *t*. They suggest that faith-based artifacts can be explicable in terms of the notion of placebo capacity: a capacity to subjectively satisfy an agent’s desire to produce the relevant effect in the presence of a belief by the agent that the entity is able to bring about this effect. For instance, amulets can be ascribed the placebo capacities to subjectively satisfy the user’s desire to dispel evil spirits in the presence of the relevant belief on the part of the agent that they can in fact dispel evil spirits. But since amulets in fact lack the capacity to dispel evil spirits, the user’s desire to dispel evil spirits can be only subjectively, but not objectively, satisfied.

The notion of placebo capacity enables us to think alternatively that **pebble<sub>1</sub>** at time *t* may not have a function to dispel evil spirits — which is a phantom function — and therefore it cannot malfunction (by Proposition 1 or 3); but it still has the placebo capacity to subjectively satisfy the user’s desire to dispel evil spirits and this capacity is a realizable entity whose realizations are nomologically possible. Moreover, if a placebo capacity can be generally characterized as a novel intentional realizable entity (to wit, a novel intentional extrinsic disposition), we can say that **pebble<sub>1</sub>** at time *t* is a canonical material artifact in virtue of bearing the placebo capacity under consideration, in alignment with a realizable-centered account of malfunctioning artifacts (see again [11] for a detail analysis of faith-based artifacts and placebo capacities within a realizable-centered framework for artifacts).

Finally, we will discuss Bahr’s [18, p. 96] “malfunctioning desideratum” for a satisfactory account of artifactual functionality, accommodating the functionality of both technical artifacts and artworks. This desideratum consists of three more specific criteria. The first specific criterion is as follows:

- (1) An account *A* should allow the ascription of the function of  $\phi$ -ing to a technical artifact, an art work or an instance of an art work *a* although *a* fulfills that function ineffectively only if there are good reasons for the assumption that *a* still fulfills the function of  $\phi$ -ing.

To illustrate criterion (1) with Bahr’s example: “If the blade of a knife is blunt, it might not be able to fulfill the function of cutting optimally, although one can still cut something with this knife. Although the knife might fulfill its function rather badly, we would nonetheless like to call cutting one of its functions” [18, p. 91].

This criterion for malfunctioning can be interpreted in terms of Proposition 2, more specifically as the case where there is some problem with the “categorical basis” of the relevant function (which is a

realizable entity) (see [6] for the notion of categorical basis of a realizable entity). To illustrate this with Example 2, on the background of either Interpretation 1 or 2, the realizable entity  $\mathbf{d}_1$  is not (or not well) realized at time  $t_2$  because the container-like structure of  $\mathbf{clay}_1$ , its categorical basis, is damaged.

The second specific criterion of the malfunctioning desideratum is as follows [18, p. 96]:

(2) An account  $A$  should allow the ascription of the function of  $\phi$ -ing to a technical artifact, an art work or an instance of an art work  $a$  although  $a$  currently does not fulfill the function due to ineffective handling only if (a) there are good reasons for the assumption that  $a$  was intentionally created for  $\phi$ -ing or  $a$  itself and/or tokens of the type  $a$  belongs to has/have regularly been used to perform the function of  $\phi$ -ing and (b) there are good reasons for the assumption that  $a$  can potentially perform the function of  $\phi$ -ing.

To illustrate criterion (2) with Bahr's example: "if I fail to push the right button to turn on my electric kettle or if I forget to plug it in or to fill it with water, the kettle will not fulfill its function of boiling water. Nevertheless [...] it is a function of the kettle to boil water, because, if the kettle had been handled correctly, it would have fulfilled its function of boiling water" [18, p. 91]. In addition: "If someone tries to open a beer bottle with a lighter and fails (which supposedly happens quite often [...]), [...] this is even a function of this particular lighter, provided that it can potentially open beer" (ibid., p. 94).

This criterion for malfunctioning can be partially interpreted in terms of Proposition 2, specifically as the case where the relevant function (which is a realizable entity) is not realized because it is not "triggered" – the cases of malfunctioning relevant to "regular use" being reserved for future work in connection with Proposition 3 (see Section 3.3). To illustrate this with Example 2,  $\mathbf{d}_1$  is not realized at time  $t_2$  because the handle of  $\mathbf{clay}_1$  is improperly held.

The third specific criterion of the malfunctioning desideratum is as follows [18, p. 96]:

(3) An account  $A$  should allow the ascription of the function of  $\phi$ -ing to a technical artifact, an art work or an instance of an art work  $a$  although  $a$  is currently not capable of  $\phi$ -ing only if (a) there are good reasons for the assumption that  $a$  was intentionally created for  $\phi$ -ing or  $a$  itself and/or tokens of the type  $a$  belongs to has/have regularly been used to perform the function of  $\phi$ -ing and (b) there are good reasons for the assumption that  $a$  can be fixed to win back its capability of  $\phi$ -ing.

To illustrate criterion (3) with Bahr's example: "If my coffee machine is broken, but not unfixable, I still want to say that it is a function of the coffee machine to make coffee" [18, p. 95]. Furthermore: "If one of my chairs has a broken leg and cannot serve as a ladder, [...] I can still ascribe the function of serving as a ladder to that chair as long as I believe that the chair can be fixed and regain its capability to serve this purpose, because it is such a regular thing to use chairs for that purpose that this function is strongly connected to these artifacts" (ibid., pp. 95-96).

Incorporating this criterion for malfunctioning into our realizable-centered account will necessitate careful consideration of the notion of what we may call "repairability", and what is expressed by Bahr in terms like "can be fixed to win back [synonym: 'regain'] its capability" and being "not unfixable". While scrutinizing the notion of repairability lies outside the purview of this paper (see, e.g., [33]), we remark that, from a realizable-centered perspective, repairability would be characterized, at first approximation, as an intrinsic disposition to regain some relevant realizable entity (see [34] for a pointer).

## 5. Conclusion

We outlined an ontological unifying approach to malfunctioning artifacts that is theoretically undergirded by the ontology of realizable entities. For this purpose, we drew upon a realizable-centered approach to artifacts and provided an ontological analysis of the malfunctioning of material canonical artifacts and material usefacts. The key idea is that an artifact is malfunctioning when some relevant

intentional realizable entity thereof is not realized. By discussing related work, we elucidated our realizable-centered account of the malfunctioning of artifacts and specified some future lines of inquiry, such as an ontological analysis of regular/conventional use and repairability within our framework.

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## Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT in order to: Grammar and spelling check, Paraphrase and reword. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the publication’s content.

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