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The interconnection between artifacts and realizable entities

Fumiaki Toyoshima^{1,*}, Adrien Barton¹, Kathrin Koslicki² and Olivier Massin²

¹ IRIT, CNRS, Université de Toulouse, Cr Rose Dieng-Kuntz, 31400 Toulouse, France

² Université de Neuchâtel, Institute of Philosophy, Espace Tilo-Frey 1, 2000 Neuchâtel, Switzerland

Abstract

Artifacts remain nebulous entities, notwithstanding their relevance to various domains such as engineering, art and archeology. In this paper we investigate the interconnection between artifacts and realizable entities, as illustrated by dispositions, functions, and roles within the framework of the upper ontology Basic Formal Ontology (BFO). More concretely, we propose the notions of *canonical artifact* (something that is intentionally produced for some purpose) and *usefact* (something that is intended to be used for some non-original purpose) which can correspond to various usages of the term “artifact”. We also characterized them in terms of *intentional realizable entities* and *novel realizable entities*: material canonical artifacts and material usefacts can be analyzed in terms of novel intentional realizable entities and a special kind of non-novel intentional realizable entities, respectively.

Keywords

artifact, realizable entity, disposition, function, role, Basic Formal Ontology (BFO)

1. Introduction

The world is replete with artifacts: technical artifacts (e.g. screwdrivers), artworks (e.g. paintings), social artifacts (e.g. the European Commission), and abstract artifacts (e.g. Shakespeare’s work *Hamlet*), to just name a few. These types of entities are usually contrasted with so-called “natural objects” such as molecules, stones, people, and planets. They are intimately connected with many kinds of entities such as intentions, agents, actions (physical and mental), capacities, functions, roles, and affordances. Artifacts are notoriously difficult to analyze because no clear consensus as of yet exists over how to capture systematically these multifaceted ontological characteristics of artifacts.

In this paper we will investigate the relationship between artifacts and *realizable entities*. Roughly, a realizable entity is a property that can be realized in associated processes of a specific correlated type in which the bearer participates. For example, the fragility of a particular glass

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* Corresponding author.

✉ toyo.fumming@gmail.com (F. Toyoshima); adrien.barton@gmail.com (A. Barton); kathrin.koslicki@unine.ch (K. Koslicki); olivier.massin@unine.ch (O. Massin)

🆔 0000-0002-4690-1221 (F. Toyoshima); 0000-0001-5500-6359 (A. Barton); 0000-0002-0868-7199 (K. Koslicki); 0000-0002-3949-4429 (O. Massin)



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can be analyzed as a realizable entity 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. A realizable entity can go unrealized: this glass can be fragile, even if it never breaks or never undergoes any shock. The notion of a realizable entity has been theoretically elaborated, notably in the upper ontology Basic Formal Ontology (BFO) [1,2,3].

Our focus on artifacts *vis-à-vis* realizable entities is motivated by the fact that, whereas artifacts are traditionally analyzed in terms of functions and intentions, an intention- and/or function-centered approach to artifacts has been recently subject to critical philosophical examination [4,5,6]. To take one example, technical artifacts may be generally characterized in terms of functions (e.g. screwdrivers and the function to turn screws), but it is at least controversial whether all kinds of artifacts (including artworks) can be also analyzed in terms of functions, or even whether they have any function at all. For that matter, a capacity-based approach to artifacts has been proposed in philosophy [5,6] and in formal ontology [7,8]; here, the notion of a capacity is supposed to be broader than the general notion of a function. Because the notion of a realizable entity (as found in BFO) can be likened to the notion of a capacity used in such previous works, a realizable-centered approach may be expected to provide a comprehensive perspective on artifacts, ranging from material to abstract ones as well as from technical ones to artworks.

This paper is organized as follows. As a preliminary, Section 2 specifies some philosophical views of diachronic identity and lays out the basic structure of BFO. Section 3 explores the interconnection between artifacts and realizable entities; in particular, between material artifacts and realizable entities in BFO. More concretely, we introduce the notions of *canonical artifact* and *usefact* to disambiguate the meaning of the polysemous term “artifact”, which is employed in distinct ways across different domains. The basic idea is that a canonical artifact is something that is intentionally produced for some purpose, while a usefact is something that is intended to be used for some non-original purpose. We also define the terms “material canonical artifact” and “material usefact” in terms of realizable entities in BFO. Section 4 discusses related work. Section 5 concludes the paper.

2. Preliminaries

2.1. Philosophical views of diachronic identity

We illustrate some philosophical views of diachronic identity with the example of a pot made out of an amount of clay which is intentionally shaped and dried at time t_1 :

- The *continuity view*: At time t_1 , this amount of clay (**clay**₁) continues to exist and comes to instantiate the kind *Pot*.²

² For the sake of terminological clarity, we will occasionally write names for particular or token-level entities in bold (e.g. “**clay**”) and names for kinds or type-level entities in italics (e.g. “*Pot*”), respectively. We will also occasionally use a subscript for entity names in BFO (e.g. “BFO:clay₁”). We also note that, in using the term “artifact” in the expression “the artifact kind *Pot*” above, we mean a canonical artifact as defined below, while remaining neutral as to whether the term “pot” and other specific artifact terms such as “screwdriver” and “paperweight” always refer to a canonical artifact or not.

- The *non-continuity* view: At time t_1 , a new material entity \mathbf{pot}_2 (which instantiates the kind *Pot*) comes into being.
 - a. The *discontinuity* view: At time t_1 , \mathbf{clay}_1 ceases to exist and a new material entity \mathbf{pot}_2 comes into being.
 - b. The *constitution* view: At time t_1 , \mathbf{clay}_1 continues to exist and a new material entity \mathbf{pot}_2 (constituted by, but distinct from, \mathbf{clay}_1) comes into being. Cf. [7]

These philosophical views of diachronic identity are important for the ontology of artifacts because production and use are usually understood under the non-continuity view and the continuity view, respectively. We will assume the continuity view in this paper to provide a systematic analysis of the relationship between production and use under the same philosophical view of diachronic identity. Note that, under the continuity view, the production of a material artifact does not imply the coming into being of a new *material* entity, but rather the coming into being of a new *realizable* entity as detailed below. However, our realizable-centered approach to artifacts can be, *mutatis mutandis*, reformulated to fit well with the non-continuity view as well (see e.g. Section 3.4).

2.2. Basic Formal Ontology (BFO): A general overview

We will use Basic Formal Ontology (BFO) [1,2,3] as a general ontological framework for our investigation. Figure 1 provides a taxonomy of classes used in this paper, including terms denoting classes that are already established within BFO as well as new terms introduced by us. In order for a class A to be a subclass of a class B (which is expressed by the indentation), all instances of A must be instances of B .

BFO includes the top-level distinction between continuants and occurrents. On the continuant side, independent continuants include material entities such as organisms and heaps of stones. A specifically dependent continuant is a continuant that depends (existentially) on at least one independent continuant. A realizable entity is a specifically dependent continuant that can be realized in associated processes of specific correlated types in which the bearer participates. Among realizable entities in BFO, we will focus on dispositions and roles in this paper (see our companion paper [9] for a detailed discussion on artifacts and BFO:functions [2], which are a kind of BFO:dispositions).

A disposition in BFO is a realizable entity that exists because of certain features of the physical makeup of the independent continuant that is its bearer. It is an “internally grounded realizable entity”: if a disposition ceases to exist, then the physical makeup of the bearer is changed.³ Examples include the fragility of a glass and the flammability of a match.

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

³ For more thoughts on dispositions, see Röhl & Jansen’s [10] and Barton et al.’s [11] works; in particular, the latter’s study of the identity of dispositions may help to better understand the issue of the individuation of realizable entities in general (see Section 4).

make-up of the bearer is thereby changed (external grounding).⁴ Briefly, a role is an externally grounded and optional realizable entity. Examples include the role of being a student and the role of a stone of marking a boundary.

On the occurrent side, a process is an occurrent that exists in time by occurring, i.e. by having temporal parts, and which depends on at least one independent continuant as participant. Examples of processes include cell division and a walk taken by a person.

BFO:*Continuant*

 BFO:*Independent continuant*

 BFO:*Material entity*

Material canonical artifact (see Section 3.4)

Material usefact (see Section 3.5)

 BFO:*Specifically dependent continuant*

 BFO:*Realizable entity*

 BFO:*Disposition*

Intention ([13]; see also Section 3.2)

 BFO:*Function*

 BFO:*Role*

Intentional realizable entity (see Section 3.2)

Novel intentional realizable entity (see Section 3.4)

Novel realizable entity (see Section 3.4)

Novel intentional realizable entity (see Section 3.4)

BFO:*Occurrent*

 BFO:*Process*

Figure 1: A taxonomy of classes used in this paper, including those imported from BFO as well as those introduced by us.

3. Characterizing artifacts in terms of realizable entities

3.1. Illustrative examples and canonical artifacts

We will explore the relationship between artifacts and realizable entities by analyzing the realizable entities that are involved in the following scenarios:

- At time t_1 , a particular amount of clay (**clay**₁) is intentionally shaped and dried to be able to contain liquid.
- At time t_1' (later than time t_1), **clay**₁ is intended to be used to contain liquid.⁵
- At time t_1'' (later than time t_2), **clay**₁ is intended to be used to hold a door.

⁴ For more thoughts on roles, see Röhl & Jansen's [10] and Toyoshima et al.'s [12] analysis of being internally/externally grounded and (non-)optionality.

⁵ Throughout this paper we employ the expression “be intended to be used to do” to mean being intended to be used to do, independently of whether it is actually used for that purpose or not. See works [7,14] for the contrast between use intention (even without an associated actual use) and actual use. Note also that, in this paper, we will employ the term “use” in a narrow sense in which use is different from production, in contradistinction with a broad sense of the term in which production is a kind of use (e.g. [15]).

- At time t_2 , a particular pebble (**pebble₂**) is intended to be used to keep papers in place. (cf. [7])

We begin by examining **clay₁** at time t_1 from the viewpoint of realizable entities. According to a traditional view of artifacts, an artifact is something that is intentionally produced for some purpose (e.g. [16]). Since our goal is to articulate multiple possible meanings of the term “artifact”, we introduce the term “canonical artifact” to refer to something that is intentionally produced for some purpose. Therefore, **clay₁** at time t_1 is a canonical artifact because it is intentionally shaped and dried for the purpose of being able to contain liquid. Below, we will scrutinize the notion of a canonical artifact, as illustrated by **clay₁** at time t_1 , in terms of realizable entities.⁶

3.2. Intentional realizable entities

To develop a realizable-based view of canonical artifacts such as **clay₁** at time t_1 , we will focus on the disposition **d₁** to contain liquid that **clay₁** comes to bear at time t_1 — such that **d₁** exists in virtue of the container-like structure of **clay₁** at and after time t_1 . As the notion of a canonical artifact is related to agent intentions as well as the idea of purpose- or goal-directedness, we will deploy Toyoshima et al.’s [13] dispositional account of intentions in combination with Hobbs & Gordon’s [17] formal theory of goals. Note, however, that our focus is on the relationship between artifacts and realizable entities and a full analysis of the intentional and goal-directed aspects of artifacts exceeds the scope of this paper.

According to Toyoshima et al.’s [13] BFO-compliant account of intentions, an intention is a disposition to act which comes into being as a result of the causal interactions between beliefs and desires. For instance: before time t_1 , some agent forms the intention (**intention₁**) — which is a disposition — to shape and dry **clay₁** in such a way as to be able to contain liquid. Reinterpreted within the BFO framework, Hobbs & Gordon’s [17] formal theory of goals states that a goal is a process type (“eventuality type” in their terms) that is associated with an agent — or arguably more precisely, with some intentional entity of an agent, paradigmatically an agent’s intention. By way of illustration, the goal that is relevant to the example involving **clay₁** at time t_1 is the process type *Clay₁ becoming capable of containing liquid* that is associated with **intention₁**.

These considerations of the intentional and goal-directed dimensions of **clay₁** at time t_1 will contribute to our analysis of the canonical artifactual character of **d₁**. First of all, **d₁** is formed as a result of the process (**process₁**) of intentionally shaping and drying **clay₁** to be able to contain liquid.⁷ Moreover, **process₁** is (part of) a realization of **intention₁** and it has as part the process of **clay₁** becoming capable to contain liquid, which is an instance of the goal *Clay₁ becoming capable of containing liquid*. We can say that **d₁** has an intentional and goal-directed

⁶ Note that, in the case of complex canonical artifacts such as cars, associated intentional acts required for the production of a canonical artifact can involve the aggregation of a multiplicity of diverse parts according to a “make plan” and a “use plan” in the sense of the work [15] (as explained in Section 4).

⁷ Here, we are using the term “being formed as a result of” to refer to the relation which is the inverse of the relation “results in formation of” from the BFO-compliant Relation Ontology (http://purl.obolibrary.org/obo/RO_0002297). These relations are, however, employed in a more general sense as holding between a continuant (not restricted to an anatomical entity) and a process.

dimension because it is connected, by way of **process**₁, with **intention**₁ and the goal **Clay**₁ *becoming capable of containing liquid*.

Based on this discussion, we define the term “intentional realizable entity” as follows:

intentional realizable entity =_{def.} A realizable entity that comes into being for a specific goal through an intentional act.

By this definition, **d**₁ is an intentional realizable entity: it comes into being through **process**₁ (which an intentional act) and it is directed towards the goal of **clay**₁ being capable of containing liquid, which can be realized in a process of **clay**₁ containing liquid.

We provide one important clarification of the term “intentional realizable entity”: its definition includes the term “goal” and “intentional act”, but contrary to Hobbs & Gordon’s intention-based theory of goals, we do *not* assume that the goal-directed dimension of an intentional realizable entity is always directly connected with the realizable entity’s intentional dimension. To see this, suppose that this pile of earth bears the disposition **d**_{ant} to house ants. While **d**_{ant} may be directed towards the goal of the pile of earth being capable of housing ants, it is questionable whether this goal-directedness can be attributed to the intention of individual ants, or even a collective intention shared by the members of an ant colony, to produce something for purpose of housing ants. Since we are interested in various sorts of artifacts, including those that are not included within the category of technical artifacts, we argue that the relationship between the intentional and goal-directed dimensions of intentional realizable entities merits careful consideration, even if it may be straightforwardly analyzable when it comes to technical artifacts (e.g. **clay**₁ at time **t**₁).

3.3. Canonical artifacts and usefacts

We said that, at time **t**₁, **clay**₁ is a canonical artifact and it comes to bear **d**₁, which is an intentional realizable entity in our terms. One may be inclined to think that the notion of a canonical artifact can be fully characterized in terms of an intentional realizable entity, i.e. that a material canonical artifact is definable as “a material entity that bears an intentional realizable entity”. However, we argue that, while bearing an intentional realizable entity is necessary for a material entity to be a canonical artifact, it is not sufficient, because there are some material entities which are not canonical artifacts in our sense of the term but which nonetheless bear intentional realizable entities.

To elaborate on this point, let us consider **pebble**₂ at time **t**₂, when **pebble**₂ is intended to be used to keep papers in place. One way to interpret this example in terms of realizable entities is to consider the role **r**₂ borne by **pebble**₂ to keep papers in place that comes into being at time **t**₂. According to Spear et al.’s [2]: “when sticks from the woods are *merely intentionally selected* to be used as chopsticks, then they do not take on or have a function at all in the BFO sense, but rather a *role*” [2, p. 126]. In a similar fashion, **pebble**₂ is merely intentionally selected to be used to keep papers in place at time **t**₂ and therefore comes to bear the role **r**₂ of holding papers in place at that time.

We can further clarify **r**₂ by introducing the intention (**intention**₂) to use **pebble**₂ to keep papers in place that comes into being at time **t**₂. (Recall that, as was explained earlier in Section 3.2, we take intentions to be a type of dispositions.) Then **r**₂ is externally grounded, as it can

cease to exist when **intention₂** ceases to exist, without necessarily involving the change of the physical make-up of **pebble₂**. In addition, **r₂** is also optional, as it exists because **pebble₂** is in the special circumstances in which **pebble₂** does not have to be, to wit, in the circumstances in which **intention₂** exists.

Now, by our definition, **r₂** is an intentional realizable entity: it is directed towards the goal of **pebble₂**'s keeping papers in place; and it comes into being through the act of intending to use **pebble₂** to keep papers in place, because “mental selection” can be construed as a kind of intentional act (see e.g. [7]). Thus, **r₂** (borne by **pebble₂** at time t_2) and **d₁** (borne by **clay₁** at time t_1) are both intentional realizable entities. Nonetheless, **pebble₂** at time t_2 is not a canonical artifact in our sense of the term, whereas **clay₁** at time t_1 is. To put it more generally, the mere fact of bearing an intentional realizable entity fails to distinguish canonical artifacts, i.e. material entities that are intentionally *produced* for some purpose, from other types of material entities that are intended to be *used* for some purpose other than the original purpose for which they were intentionally produced.

To characterize this distinction between canonical artifacts and other “use-based” types of entities, we introduce the term “usefact” to refer to something that is intended to be used for some purpose other than the original purpose for which it was intentionally produced (if any). In effect, usefacts are related to “naturefacts” in anthropology [18] and “ecofacts” in archeology (e.g. [19]) (see also Preston's [20] characterization of naturefacts and ecofacts in these domains).

The notion of a usefact is nevertheless more general than those of a naturefact and an ecofact in two respects. Firstly, being a usefact is based on some use intention, but not necessarily on an associated actual use. Secondly, not only natural objects (e.g. **pebble₂**) but also canonical artifacts can be usefacts. To illustrate this point, consider **clay₁** at time t_1' (when it is intended to be used to contain liquid) and **clay₁** at time t_1'' (when it is intended to be used to hold a door); note that, at both times, **clay₁** is a canonical artifact, as it became so at time t_1 . We say that **clay₁** is a usefact at time t_1'' , but not at time t_1' , because the purpose for which it is intended to be used at time t_1'' is different from the original purpose for which it was intentionally produced (i.e. for the purpose of containing liquid), while the purpose for which it is intended to be used at time t_1' is the same as the original purpose for which it was intentionally produced.

3.4. Material canonical artifacts and novel intentional realizable entities

In our view, the notion of the “novelty” of a realizable entity can serve to capture the distinction we just outlined between canonical artifacts and usefacts. To see this, we contrast the disposition **d₂** of **pebble₂** to keep papers in place with the role **r₂** of **pebble₂** to keep papers in place (introduced in Section 3.3). (Recall that dispositions are internally grounded realizable entities, while roles are externally grounded and optional ones.)

On the one hand, **d₂** is internally grounded, as **d₂** ceasing to exist necessarily involves the change of the physical make-up (solid structure) of **pebble₂**. Moreover, **d₂** can exist even in the absence of any associated use intention such as **intention₂** (e.g. before time t_1') and **d₂** is not an intentional realizable entity, as it does not come into being through an intentional act. On the other hand, **r₂** is externally grounded, as **r₂** ceasing to exist does not necessarily involve the change of the physical make-up of **pebble₂** – in particular, when **intention₂** ceases to exist. And, as we saw in Section 3.3, **r₂** is an intentional realizable entity.

Notwithstanding these ontological differences, **d**₂ and **r**₂ are intimately connected with each other in the sense that, whenever **r**₂ is realized in a particular process, then **d**₂ is realized in the same process. In short, **r**₂ is not a “novel” realizable entity for its bearer **pebble**₂ in the sense that any realization of **r**₂ is a realization of **d**₂, which exists *before* **r**₂ comes into being. At time *t*₂, **pebble**₂ comes to bear **r**₂, which is an intentional realizable entity; however, **pebble**₂ does not become a canonical artifact, but rather a usefact, at time *t*₂ owing to the “non-novelty” of **r**₂ for its bearer **pebble**₂.⁸

Let us now turn to the disposition **d**₁ to contain liquid that **clay**₁ comes to bear at time *t*₁, as compared to the role **r**₂ to keep papers in place that **pebble**₂ comes to bear at time *t*₂. Whereas **d**₁ and **r**₂ are both intentional realizable entities, **clay**₁ at time *t*₁ (unlike **pebble**₂ at time *t*₂) bears no realizable entity existing before **d**₁ comes into being and such that, if **d**₁ is realized in a particular process, then it is realized in the same process. Unlike **r**₂, **d**₁ is an intentional realizable entity whose realization is of a “new” kind for its bearer **clay**₁. At time *t*₁, **clay**₁ is a canonical artifact in virtue of its bearing **d**₁, because **d**₁ is an intentional realizable entity that is “novel” for its bearer **clay**₁.

To spell out the idea of the “novelty” of intentional realizable entities involved in canonical artifacts, we introduce the terms “novel realizable entity” and “novel intentional realizable entity” as follows:

novel realizable entity =_{def.} A realizable entity *r* such that the bearer has no realizable entity *r*' such that (i) *r*' exists before *r* comes into being and (ii) if *r* is realized in a process, then *r*' is realized in the same process.⁹

novel intentional realizable entity =_{def.} An intentional realizable entity that is a novel realizable entity.

According to the definitions of these two terms, **d**₁ is a novel intentional realizable entity but **r**₂ is not, although they are both intentional realizable entities. We can now provide a general realizable-based characterization of canonical artifacts by defining the term “material canonical artifact” as follows:

material canonical artifact =_{def.} A material entity that bears a novel intentional realizable entity.

By this definition, **clay**₁ at (and after) time *t*₁ is a material canonical artifact in virtue of its bearing **d**₁; but **pebble**₂ at time *t*₁' is not, despite its bearing **r**₂ (which is an intentional but “non-novel” realizable entity, where the term “non-novel realizable entity” is defined as “a realizable entity that is not a novel realizable entity”).

⁸ Note that the same argument, *mutatis mutandis*, applies to **clay**₁ at time *t*₁'. To see this, consider the disposition **d**₁' to hold a door open that **clay**₁ bears after time *t*₁, insofar as the physical makeup (e.g. solid structure) of **clay**₁ remains unchanged; and the role **r**₁' to hold a door open that **clay**₁ comes to bear at time *t*₁', when an associated use intention comes into being.

⁹ In future work we will further elucidate our notion of (non-)novelty of realizable entities by considering the identity of processes in BFO (e.g. [21]).

We provide two clarificatory remarks on our way of analyzing the relation between canonical artifacts and realizable entities. Firstly, our analysis of canonical artifacts in terms of novel intentional realizable entities under the continuity view of diachronic identity can be, *mutatis mutandis*, reformulated to fit the non-continuity as well. According to the definition of novel realizable entities, when a realizable entity comes into being simultaneously with its bearer, it is “trivially novel”, since the bearer did not exist before then, nor did any realizable entity of the bearer. For an example illustrating this argument, see our discussion of functions in BFO in our companion paper [2].

Secondly, we characterize material canonical artifacts in terms of novel intentional *realizable entities*, although we have been treating the *disposition* \mathbf{d}_1 of \mathbf{clay}_1 at time t_1 as a driving example of a novel intentional realizable entity. This is because our notion of a canonical artifact is not restricted to the category of technical artifacts, where production typically involves physical modifications, such as shaping and drying \mathbf{clay}_1 (cf. [22]). A physical modification is an act of changing the physical makeup of a material entity and a disposition exists because of certain features of the physical makeup of the bearer. In the case of non-technical canonical artifacts, by contrast, production may arguably involve acts without physical modification, which may be described as mere “selections”.

3.5. Material usefacts and a special kind of non-novel intentional realizable entities

We now turn to a closer examination of the notion of a usefact. In particular, we define the term “material usefact”, which denotes a more restricted subclass of usefacts. One naïve attempt is to define this term as “a material entity that bears a non-novel intentional realizable entity”. Certainly, this simple definition of material usefacts would have the desirable consequence that \mathbf{pebble}_2 at time t_1' is a material usefact in virtue of its bearing \mathbf{r}_2 , which is a non-novel intentional realizable entity.

The naïve definition of material usefacts may be nonetheless too broad. To illustrate this, consider the role \mathbf{r}_1 to contain liquid that \mathbf{clay}_1 comes to bear at time t_1' .¹⁰ Like \mathbf{r}_2 , \mathbf{r}_1 is a non-novel intentional realizable entity. In particular, \mathbf{r}_1 is a non-novel realizable entity: if \mathbf{r}_1 is realized in a process, then \mathbf{d}_1 is realized in the same process. According to the naïve definition of “material usefact”, \mathbf{clay}_1 at time t_1' is a material usefact in virtue of its bearing \mathbf{r}_1 . This would contradict our notion of a usefact as something that is intended to be used for some purpose *other than the original purpose for which it was intentionally produced*.

Therefore, usefacts should be considered as material entities that bear a specific kind of non-novel intentional realizable entities. To this end, we introduce the relation of “being non-novel because of” between two realizable entities as follows:

¹⁰ We can justify the coming into being of \mathbf{r}_1 (borne by \mathbf{clay}_1) at time t_1' , in the same way as we justified the coming into being of \mathbf{r}_2 (borne by \mathbf{pebble}_2) at time t_2 in Section 3.3. One might want to deny the existence of \mathbf{r}_1 on the grounds that it is “redundant” because of the disposition \mathbf{d}_1 to contain liquid which \mathbf{clay}_1 has borne since time t_1 . But this argument against the existence of \mathbf{r}_2 would lead to denying the existence of \mathbf{r}_1 , as \mathbf{r}_1 would be “redundant” because of the disposition \mathbf{d}_2 of \mathbf{pebble}_2 to keep papers in place. Although the individuation of realizable entities is a topic that requires further discussion (see Section 4 for a brief discussion), it can be plausibly prescribed that the principle for individuating them must be consistent. We postulate consistently the existence of both \mathbf{r}_1 and \mathbf{r}_2 in this paper.

A realizable entity r is non-novel because of a realizable entity r'
=def. There exists some independent continuant 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.

The definition of this relation enables us to classify non-novel intentional realizable entities
(such as \mathbf{r}_1 and \mathbf{r}_2) into the following two types:

- Non-novel because of some novel intentional realizable entity: e.g. \mathbf{r}_1 is non-novel
because of \mathbf{d}_1 (borne by \mathbf{clay}_1 at time t_1 ').
- Non-novel because of some realizable entity that is not a novel intentional realizable
entity: e.g. \mathbf{r}_2 is non-novel because of \mathbf{d}_2 (borne by \mathbf{pebble}_2 at time t_2).

Based on the idea that material usefacts can be characterized as bearing the second type of
non-novel intentional realizable entities, we define the term “material usefact” as follows:

material usefact =def. 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.

By this definition, \mathbf{pebble}_2 at time t_2 is a material usefact in virtue of its bearing \mathbf{r}_2 , but \mathbf{clay}_1
at time t_1 ' is not despite its bearing \mathbf{r}_1 .¹¹

4. Discussion of related work

Although there is a large body of literature on artifacts in many domains, the notion of a
canonical artifact can be related to a long-standing standard account of artifacts, as it can be
traced back to Hilpinen's [16] classical work on the philosophy of artifacts. As we said in Section
1, a traditional intention- and/or function-centered approach to artifacts has been critically
examined in philosophy [4,5,6]. Relatedly, we argued that the linkage between the intentional
and goal-directed dimensions that are involved in intentional realizable entities deserves close
scrutiny (see Section 3.2) and we explore the relationship between functions and artifacts in
more detail in our companion paper [9].

In formal ontology, there are some existing BFO-compliant definitions of the terms “artifact”
and “material artifact”.¹² These definitions tend to characterize artifacts in terms of

¹¹ In connection with Footnote 8, this definition yields the desired consequence that \mathbf{clay}_1 at time t_1 ' is a material
usefact, as the role \mathbf{r}_1 ' to hold a door open (borne by \mathbf{clay}_1 at time t_1 '') is non-novel because of the disposition \mathbf{d}_1 ' to
hold a door open (borne by \mathbf{clay}_1 after time t_1) and \mathbf{d}_1 ' is not a novel intentional realizable entity because it is not
an intentional realizable entity.

¹² Examples of BFO-compliant definitions of the term “artifact” include: “A material entity created or modified or
selected by some agent to realize a certain function or role” [23, p. 1]; “Something that is deliberately designed (or,
in certain borderline cases, selected) by human beings to address a particular purpose” [1, p. 3]; and “A material
entity that has been intentionally selected by some agent to serve in attaining some end and is recognized in some
community as having been created for some purpose” [24, p. 26].

Examples of BFO-compliant definitions of the term “material artifact” include: “An object deliberately created
to have a certain function” [25, p. 7]; and “A material entity that was designed by some agent to realize a certain
function” [26].

BFO:functions and the BFO notion of function may fail to mesh well with the continuity view of diachronic identity. By contrast, we articulated the notion of a canonical artifact in terms of novel intentional realizable entities, a notion that is not restricted to what we may call “design BFO:functions”, in a way that is compatible with the continuity view. A detailed analysis of functions in BFO is presented in our companion paper [9].

As for related work outside the BFO context, Borgo et al. [27, p. 232] highlight that there is a “fundamental choice in ontology structuring” as to technical artifacts: “via a constitution relation” (which amounts to the constitution view in our terms) or “via an intentional property”. We took the latter approach by elaborating the notion of an intentional realizable entity, i.e. a type of intentional property, from the perspective of the continuity view.

To bring out the unique features and flexibility of our analysis of artifacts, we briefly discuss three existing definitions of technical artifacts, as highlighted by Borgo et al. [27] as “ontological” [7], “engineering” [28], and “technological” [15]. For Borgo & Vieu [7], a technical artifact is an entity that is constituted by some material entity through an agent’s two (possibly concurrent) intentional acts: the mental selection of that material entity and the attribution of a capacity (synonym: “technical quality” [27]) to the material entity. At time t_2 , for example, the technical artifact **paperweight**₃ (constituted by **pebble**₂) comes into being because **pebble**₂ is mentally (and intentionally) selected and (at the same time) the capacity to keep papers in place is intentionally attributed to **pebble**₂: “The paperweight exists as soon as the agent selects it on the beach” [7, p. 292].

In our framework, B&V’s ontological notion of a technical artifact may be characterized as a material entity that bears some kind of (novel or non-novel) intentional realizable entity, which allows the entity in question to be classified either as a canonical artifact or as a usefact. To motivate such a broad understanding of technical artifacts, suppose that, at time t_2' , **pebble**₂ is intentionally shaped in the form of a cube. On the one hand, **pebble**₂ at time t_2' may be interpreted as a material canonical artifact, in case the disposition **d**₂ of **pebble**₂ to keep papers in place ceases to exist owing to intentional shaping and a novel intentional disposition (say, to keep papers in place tightly) comes into being, at time t_2' . On the other hand, it may be interpreted as a material usefact, in case **d**₂ “survives” intentional shaping and continues to exist even after time t_2' . Generally speaking, the individuation of realizable entities (and thus the existence of **d**₂) is open to multiple distinct interpretations and this vexed issue can sometimes lead to indeterminacy between cases in which an entity is classified as a canonical artifact and cases in which an entity is classified as a usefact.

We think however that the distinction between canonical artifacts and usefacts is theoretically tenable. For instance, this distinction is fundamentally based on the distinction between production and use, and the production/use distinction is of great theoretical significance, as is witnessed by the fact that production and use are usually associated with the non-continuity view and the continuity view, respectively (see Section 2.1).

For Kitamura & Mizoguchi [28], a technical artifact is a material entity that comes into being through an “intentionally performed production process”: a process in which some agent physically changes the material entity with the goal of producing something that can manifest an intended behavior. Because it is related to production and physical change, the engineering notion of a technical artifact proposed by these authors can be construed in our framework in terms of material entities that bear novel intentional dispositions.

For Houkes & Vermaas [15], a technical artifact is a material entity (i) which is created through the carrying out by some agent of a “make plan” for a material entity with some physical description and (ii) for which a “use plan” exists. Regarding the technical terms therein: “A use plan for a physical object is a goal-directed series of considered actions, where some of the actions involve interacting with the object [27, p. 223, italics omitted]. A make plan is: “a use plan for a set of materials and a set of tools that has the aim to create a physical object *a* that meets a specific physical description (...). Carrying out a make plan for a physical object *a* counts as producing *a*” [27, p. 224].

H&V’s account of technical artifacts revolves around the notion of “plan”, whose extensive discussion goes beyond the scope of this paper. Nevertheless, because of its appeal to physical description and production, H&V’s technological notion of a technical artifact could be also be subsumed in our framework under the notion of a material entity that bears a novel intentional disposition.

Finally, artifacts have also been discussed from a formal perspective. Examples of such works include a formal theory of artifacts and their manipulations (e.g. design and use) [29] and formal frameworks for comparing theories of artifacts [30,31]. In relation with these works, it will be a valuable direction for future research to formalize our realizable-based analysis of artifacts in alignment with the logical specifications of BFO.

5. Conclusion

This paper investigated the interconnection between artifacts and realizable entities, as found in the upper ontology Basic Formal Ontology (BFO). For this purpose, we elaborated the notions of “canonical artifact” (something intentionally produced for some purpose) and “usefact” (something intended to be used for some non-original purpose), respectively, in terms of novel intentional realizable entities and a special kind of non-novel intentional realizable entities. The relationship between canonical artifacts and usefacts thus provides a fertile ground for a systematic, realizable-centered study of multifarious artifacts.

This work is a first step towards our realizable-centered ontology of artifacts, together with our companion paper on artifactual functions [9]. In future research, we will explore other kinds of artifacts in addition to technical and material artifacts. Examples include trenches created during the First World War, information systems [32] and artworks such as novels, which can have multiple copies [33]. The study of such non-material artifacts may require developing a general ontology of abstract and concrete entities [34].

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