The Four Dimensions of Artifacts

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Abstract

The aim of this paper is to build an upper-level ontology of artifacts. To this end, two formal tools are employed: theory of consequence operation and ontology of states of affairs. It is argued that the adequate representation of an artifact consists of the representation of the artifact's purposes, the representation of its design, the representation of the background knowledge according to which it has been designed, and the representation of instructions of use relevant for that artifact. I submit a series of constraints to be satisfied if our production and use of artifacts are to be rational activities. Since mereology is claimed to be an important part of every theory of artifacts, I sketch a few preliminary remarks on the prospects of formulating the mereology for the functional parthood. In particular, I explain why the principle of transitivity, the axiom of general sum, and the supplementation principles are false for that relation. Finally, the ontology of artifacts is evaluated against the desiderata formulated by P. Vermaas and W. Houkes for theories of artifact functions.

Imagine that the knowledge modeller complains to the philosopher about her headaches with artifacts. The latter persuades her that philosophical ontology provides universal and unique tools for representing knowledge on all conceivable kinds of objects. The knowledge modeller decides to corroborate her new conviction. She adopts mereology, one of the formal tools recommended by philosophers, in order to model some domain of artifacts. To her surprise, she finds out that given a collection of artifacts she may combine them into only one artifact because of the extensionality of the mereological parthood. To her even greater surprise, she discovers that the object called 'the mereological sum of all diodes in the world' is an artifact and the description 'the mereological sum of all diodes and all bicycles' denotes also a single artifact. The knowledge modeller lodges a complaint against these absurdities with her friend. What will the philosopher say?

I would say that it is well known that the standard system of mereology (devised by Stanisław Leśniewski as a substitute for set theory) is not directly applicable to all domains of objects. If you do not use it in accordance with Leśniewski's prescription, you may apply it to abstract objects such as regions of space or periods but not to artifacts.[1] Artifacts have functional parts that are conceptually different from mereological parts. In order to give a sound definition of functional part I construct a formal ontology of artifacts. The resulting ontology is a tentative proposal of a reference ontology for the domain of artifacts (cf. Guarino 1998). My proposal is both ontological and representational as it answers both the question 'What is an artifact?' and the question 'How to speak about artifacts?'

Methodology

Artifacts are methodologically awkward entities. One of the problems they pose is exceptionally troublesome as it occurs at the very beginning of every conceptualisation of the realm of artifacts. I bear in mind the following classificatory problem: which objects are, and which are not artifacts? Admittedly, p a r t i c u l a r answers abound. Hammers, cars, and sculptures are artifacts. Electrons, human beings, and icebergs are not artifacts. Nonetheless, philosophers' attempts to give a g e n e r a l answer remain unsatisfactory. It is still debatable whether definitions, songs, computer programs, or political parties are artifacts.

Pieter Vermaas and Wybo Houkes have recently suggested a methodological strategy of developing theories of artifacts (cf. Vermaas and Houkes 2003: 263-265). I transformed their proposal into a heuristic defined by 1.1.

(1.1)

(i) Start with the phenomenology of non-controversial examples of artifacts!
(ii) Generalise the phenomenology!
(iii) Expand your generalisation from (ii) into an axiomatic system!
(iv) Derive the consequences from the axioms!
(v) Compare those consequences with the phenomenology!
(vi) If, but only if, you detect any s e r i o u s divergences at step (v), repeat the whole procedure modifying step (i), step (ii), or step (iii)! Otherwise, you have at your disposal a tentative theory of artifacts.

The liberal attitude motivating step (vi) comes from my pessimistic belief to the effect that the domain of artifacts (if we include therein both works of art and technical

[1] Applying mereology to regions of space Casati and Varzi (Casati and Varzi 1999) claim that (i) the standard mereology is meant to capture the broad notion of parthood, and that (ii) other narrower notions will emerge when some additional conditions are imposed. Here I search for these additional conditions.

artifacts) is so diversified that it is impossible to provide any general account concordant with all our reliable beliefs about artifacts. My overall epistemological attitude bears a close resemblance to the methodology of ontology of the material world employed by Theodore Sider:

> One approaches metaphysical inquiry with a number of beliefs. Many of these will not trace back to empirical beliefs, at least not in any direct way. These beliefs may be particular, as for example the belief that I was once a young boy, or they may be more general and theoretical, for example the belief that identity is transitive. One then develops a theory preserving as many of these ordinary beliefs as possible, while remaining consistent with science. There is a familiar give and take: one must be prepared to sacrifice some beliefs one initially held in order to develop a satisfying theoretical account. But a theoretical account should take ordinary beliefs as a whole seriously, for only ordinary beliefs tie down the inquiry. (Sider 2001: xvi)

It is a crucial assumption of the four-dimensional ontology of artifacts that it primarily concerns artifact-types and not artifact-tokens (instance-level artifacts). I follow here the Aristotelian cliché to the effect that there is no science about particulars as particulars: *non datur scientia de individuo ut individuo* (*Ethica Nicomachea* 1080b, *De anima* 417b). As Randall Dipert observed some time ago (Dipert 1993: 16, 36), we should speak rather about artifactual aspects of objects than about artifacts themselves. The notion of artifact-type is used here to gather such artifactual aspects of objects. In what follows when I use the term 'artifact', I will refer to artifact-types unless otherwise explicitly stated.

Finally, I ought to emphasise that the temporal aspect of artifacts will be neglected in this paper. This will entail that all temporal relativizations and indices will be omitted.

Formal Tools

In the course of the exposition, I will need two formal tools. First, I presuppose a simple inference tool capable of encompassing various patterns of reasoning we employ while disputing about artifacts. In order to serve this need I will apply the notions of the standard theory of consequence. The details of the theory might be found in (Wójcicki 1984). I believe that it is in principle feasible to determine the consequence operation C determined by the rules of inference we use when we reason about artifacts. In the case of technical artifacts, C should contain at least a causal logic associated with some temporal logic.

The second formal tool is a formal ontology of objects and states of affairs. Very roughly speaking, one may say that, as the former are ontic counterparts of proper names, so the latter are ontic counterparts of sentences. To put it in a different way, while proper names are linguistic representations of objects, sentences are linguistic representations of states of affairs. Thus, that George W. Bush is wise is a state of affairs and George W. Bush is an object. I assume that the relation of representation is a function. For instance, the sentence 'Warsaw is the capital of Russia' represents the state of affairs that Warsaw is the capital of Russia, but not the state of affairs that Warsaw is the beautiful capital of Russia or the state of affairs that Warsaw is a capital. I do not assume that the function of representation is injective. There might be states of affairs that are represented by more than one sentence. I do not assume that this function is total. There might be sentences that do not represent any state of affairs. If a sentence φ is true and φ represents a state of affairs x, then I will say that x *is the case*. If a sentence φ is false and φ represents a state of affairs x, then I will say that x *is not the case.*

I employ in this paper a version of the ontology of states of affairs defended by Roman Ingarden (Ingarden 1965). Here only a brief summary of that ontology might be presented; for a complete exposition, I refer the reader to (Garbacz 2003). The inventory of my neo-ingardenian ontology contains two kinds of entities: states of affairs and objects, and two primitive relations: parthood and occurrence. I will say that one state of affairs is *part of* (*obtains in*) another and that an object *occurs* in a state of affairs. The state of affairs that George W. Bush is handsome is part of the state of affairs that George W. Bush is a handsome son of George Bush. George W. Bush occurs in the state of affairs that George W. Bush is handsome. George W. Bush and George Bush occur in the state of affairs that George W. Bush is a handsome son of George Bush.

Let S and O be two disjoint sets. Let $\leq\subseteq S\times S$ and $\boldsymbol{O}$: $S \rightarrow \wp(O)$. A quadruple $\langle S, O, \leq, \boldsymbol{O}\rangle$ is called a *neo-ingardenian ontology of states of affairs and objects* if it satisfies the constraints 2.1-2.7 below. Under the intended interpretation, the set S contains states of affairs and the set O contains all objects occurring in these states of affairs. The expression '$x\leq y$' means 'A state of affairs x is part of (obtains in) a state of affairs y'. The set of all objects occurring in a state of affairs x is denoted by $\boldsymbol{O}(x)$. If $X\subseteq S$, $\boldsymbol{O}(X) := \{o\in O: \exists x\in X\, o\in\boldsymbol{O}(x)\}$. The "dual" function to $\boldsymbol{O}$ is the function $\boldsymbol{S}$: $\boldsymbol{S}(o):=\{x\in S: o\in\boldsymbol{O}(x)\}$.

(2.1) The relation $\leq$ is a partial order.

It might be argued that the state of affairs that (George Bush is a Republican and George W. Bush is a Republican) is the join (under $\leq$) of the state of affairs that George Bush is a Republican and the state of affairs that George W. Bush is a Republican.

Let $\boldsymbol{W}$ denote the set of all maximal ideals in $\langle S, \leq\rangle$.[2] I argue in (Garbacz 2003) that elements of $\boldsymbol{W}$ might be construed as possible worlds provided that conditions 2.2, 2.3, and 2.7 hold. I will say that a state of affairs x is *compossible with* a state of affairs y if there is a possible world $W\in\boldsymbol{W}$ such that $x, y\in W$.

(2.2) $\boldsymbol{W}\neq\emptyset$.

[2] A non-empty set $X\subseteq S$ is an *ideal in* $\langle S, \leq\rangle$ iff

(i) if $y\in X$ and $x\leq y$, then $x\in X$,

(ii) if $x, y\in X$, then there exists the unique join$_{\leq}$ of x and y (i.e. the lowest upper bound of $\{x, y\}$ with respect to $\leq$) which belongs to X. The join of x and y will be denoted as usual by $x\vee y$.

(2.3) $S=\sum \boldsymbol{W}$.

2.3 entails that all states of affairs are possible. As a result, some sentences do not represent any state of affairs.

(2.4) If $x \leq y$, then $\boldsymbol{O}(x) \subseteq \boldsymbol{O}(y)$.

(2.5) $\forall x \in S\ \boldsymbol{O}(x) \neq \emptyset$.

(2.6) $\forall o \in O\ \boldsymbol{S}(o) \neq \emptyset$.

Let $W \in \boldsymbol{W}$. I define $\boldsymbol{Rel}(o_1, o_2, \ldots, o_k, W) := \{x \in W: \boldsymbol{O}(x) = \{o_1, o_2, \ldots, o_k\}\}$. The set $\boldsymbol{Rel}(o_1, o_2, \ldots, o_k, W)$ contains all states of affairs from W in which objects $o_1, o_2, \ldots, o_k$ occur.

(2.7) If $\boldsymbol{Rel}(o_1, o_2, \ldots, o_k, W) \neq \emptyset$, then $\exists y \in W\ y = \sup_{\leq} \boldsymbol{Rel}(o_1, o_2, \ldots, o_k, W)$.

Ingarden argues in (1965) that the *relation* among objects $o_1, o_2, \ldots, o_k$ (in a world W) is the state of affairs $\sup_{\leq} \boldsymbol{Rel}(o_1, o_2, \ldots, o_k, W)$. Thus, 2.7 is the claim to the effect that every k-tuple of objects is related by some state of affairs.

In this paper, I will need the notion of the involvement relation.

(2.8) $X \preccurlyeq Y \equiv \forall x \in X\ \exists y \in Y\ x \leq y$.

'$X \preccurlyeq Y$' is to be read as 'A set X of states of affairs *involves* a set Y of states of affairs'. Verify that the relation of involvement is reflexive and transitive. If $X \preccurlyeq Y$ and $X \neq Y$, I will say that X *strictly involves* Y (written: $X \prec Y$).

Other Primitives

Without any further explanation, I will speak about agents, intentional agents, and communities of intentional agents. An *agent* is an object that is able to bring it about that some state of affairs is the case. An *intentional agent* is an agent who has some beliefs and some wishes. An intentional agent x *knows* that y is the case iff x rationally believes that y is the case. If x rationally wishes y to be the case, then x knows what it would be for y to be the case. An intentional agent is *rational* iff her beliefs and wishes are rational. An intentional agent x *communicates* to an intentional agent y that z is the case if x brings it about that y believes that z is the case. A *community of intentional agents* is such collection X of intentional agents that (i) the members of X believe that they belong to X, (ii) the members of X do not wish not to belong to X, and (iii) they communicate to each other that they have some beliefs and wishes. In what follows, I will speak about purpose ascriptions made by such communities. A community X of intentional agents *ascribes y as a purpose of z* iff (i) some members of X believe that y is a purpose of z, (ii) they wish other members of X to have the same belief, and (iii) the former are able to bring it about that the latter believe that y is a purpose of x. An analogous definition may be formulated for the relation: a community X of intentional agents *ascribes y as an instruction of use for z*.

Consequently, besides the notion of consequence operation and the notion of state of affairs, the four-dimensional approach takes for granted the following notions as primitives: 'x (*rationally*) *believes that* a state of affairs y is the case', 'x (*rationally*) *wishes* a state of affairs y to be the case', 'x *brings it about that* a state of affairs y is the case', 'x *is able to bring it about that* a state of affairs y is the case'.

In order to expose some of the conceptual links between these new primitives and the primitives from the previous section I assume the following claims as axioms:

(3.1)

(i) If x brings it about that y is the case and z is part of y, then x brings it about that z is the case.

(ii) If x brings it about that y is the case and brings it about that z is the case, then x brings it about that $y \vee z$ is the case.

(3.2)

(i) If x is able to bring it about that y is the case and z is part of y, then x is able to bring it about that z is the case.

(ii) If x is able to bring it about that y is the case and able to bring it about that z is the case, then if y is compossible with z, then x is able to bring it about that $y \vee z$ is the case.

(3.3)

(i) If a rational agent x knows that y is the case and knows that z is the case, then x knows that $y \vee z$ is the case.

(ii) If a rational agent x rationally wishes y to be the case and rationally wishes z to be the case, then x rationally wishes $y \vee z$ to be the case.

Ontology

Following 1.1, I begin with a short description of some technical artifact. The example has been chosen for its simplicity and intuitive appeal.

> On a train, John writes a philosophical paper on his laptop. He bought it since he believes that the most fruitful ideas come to his mind while he travels. He saw it many times that other people make notes on a train. His fellow philosophers advised him that this very brand of laptop would best serve his needs. John considers his laptop a reliable device since he was told that it has been designed on the ground of the up-to-date know-how in computer science. He has barely any idea about its design, but he does not encounter any serious problems with it since he has carefully read the manual and knows its instructions of use. Sometimes he uses it as a paperweight but he does not believe that this is a proper function of his laptop.

Now I will generalise this phenomenology (cf. 1.1(ii)). Artifacts are objects produced on purpose.[3] Claiming that artifacts are objects, I claim that they are not state of affairs. I do not deny that some artifacts might be events or processes. We produce artifacts in order to achieve by means of them some aims we find important. Some of these aims engage producing other artifacts, but some reach beyond the realm of artifacts. For example, we produce microchips in order to produce computers, and we produce

[3] Strictly speaking, we produce tokens of artifacts and not artifacts (i.e. artifact types) themselves. However, when we produce (in the literal sense of "produce") a token of an artifact x, we also produce (in some derivative sense of "produce") the artifact type x.

computers in order to produce, say philosophical papers, but the latter are produced for other purposes than producing some further artifact. If we produce an artifact *x* in order to produce an artifact *y*, I will say that *x* is *artifact-oriented*. If we produce an artifact *x* for some other purpose than producing another artifact, I will say that *x* is *human-oriented*.

When we speak about artifacts, we usually have in mind human-oriented artifacts. So first, let us focus on them. Artifacts such as hammers, cars, and space ships are produced by rational agents. We produce them on the ground of their designs, which are supposed to make our production more efficient. We produce artifacts and construct their designs referring to some background knowledge relevant for this kind of artifacts. This knowledge is supposed to guarantee that artifacts help us to achieve the aims for which they were produced, or at least it is supposed to make it more probable that we achieve those aims. We may achieve those aims if we follow the instructions of use determined by artifacts' designs and the respective background knowledge.

The most suitable candidate for the ontological category of purposes is the category of state of affairs. To be more precise, *x* is a *purpose of y* if *x* is a state of affairs and there is some intentional relation between *x* and *y*. If *y* is an artifact, then a purpose of *y* is a state of affairs *x* intentionally ascribed to *y*. At first sight, a purpose may be ascribed to an artifact by a user of the artifact, or by its designer(s), or by a community of intentional agents, which includes the designer(s)[4] and the users of the artifact. However, if an individual user of an artifact were in a position to determine the purposes of the artifact, then contrary to our common sense beliefs such ascriptions would not be ontologically stable or socially communicable. Furthermore, the important distinction between proper and accidental purposes would then disappear. On the other hand, if the designer(s) of an artifact were in a position to determine all purposes of the artifact, then contrary to our common sense beliefs it would not be possible for the users of the artifact to invent its new purposes. Consequently, I contend that purposes are ascribed to artifacts by communities of intentional agents.

Being an artifact is then a social fact, and as such is relative to a community of intentional agents. The collective process of purpose ascriptions might be described roughly as follows. A designer of an artifact *x* interprets her product saying what *x* is for. Saying that, she either addresses the request that was explicitly expressed to her or comes up with *x* advertising it as a means to serve such and such needs. Both kinds of elucidations are assessed by *x*'s initial users or/and by experts in the domain of knowledge relevant for *x* (see below). The former simply use it and examine what needs *x* actually serves. The latter evaluate the designer's declaration against their expertise. The users or/and the experts determine to what extent (if to any) the designer was right in her declaration and, in some cases, what other purposes *x* might also serve. Other intentional agents either imitate the former or trust the latter. In this way, the community of intentional agents establishes what purposes *x* actually has.

The purposes intentional agents are eager to achieve differ from the purposes ascribed to artifacts. The relation between an intentional agent and her purpose need not be grounded in the nature of the purpose or in the nature of the agent. On the other hand, it might be argued that the relation between an artifact and its purpose is grounded in the nature of the purpose and in the physical structure of the artifact. More precisely, it is reasonable to expect that communities of rational agents do not ascribe every imaginable purpose to a given artifact, but their ascriptions are governed by some constraints. In what follows, I will confine my attention to artifacts used by such communities. Some of the constraints in question reveal the fact that a purpose ascribed to an artifact is always relative to a user of an artifact. Consider the case when I use a digital photocopier with a scanner. If I am a beginner and I know nothing about scanning, then the state of affairs that Paweł Garbacz scans a copy of his paper *The Four Dimensions of Artifacts* is not for me a purpose of the photocopier. I have no idea of what it would be for the photocopier to scan something. But when I carefully read the manual, I will get to know what it would be for that state of affairs to be the case. The respective state of affairs may be ascribed to the photocopier as one of my purposes. Generalising, a community of rational agents do not ascribe a purpose *x* to an artifact *y* for a user *z* unless *z* is able to wish *x* to be the case. And if *z* does not know what it would be for *x* to be the case, then *z* cannot wish *x* to be the case.

First, instead of speaking about purposes *simpliciter*, we should use the phrase: *x* is a purpose of an artifact *y* relative to an intentional agent *z*. Secondly, whatever your account of rationality might be, it seems reasonable that the following doxastic constraint should hold.

(4.1$_C$) If *x* is a purpose of an artifact *y* for an intentional agent *z*, then *z* knows what it would be for *x* to be the case.

Other constraints (marked with the letter $_C$) on various aspects of artifacts are listed below. Taken together, they guarantee that we speak about artifacts used by rational agents.

Since artifacts are not made in vain, I claim that a community of rational agents ascribes to every artifact it uses a purpose for which the artifact is produced. In order to keep the ontological problem apart from its representational counterpart I will use the Times New Roman typeface when I address the former and `the Courier New typeface` when I address the latter. Let L_A be a predicate logic language to speak and reason about artifacts. Then the set S_A contains all states of affairs represented by sentences from L_A. Let a set *Purpose*(*x*, *y*) $\subseteq S_A$ contain all purposes of an artifact *x* for an intentional agent *y*. Respectively, let a set `Purpose(x, y)` $\subseteq L_A$ contain sentences that represent the states of affairs from *Purpose*(*x*, *y*).

[4] For a theory of collective authorship, see (Hilpinen 1993).

(4.2$_C$) For every artifact x, there is an intentional agent y such that $Purpose(x, y) \neq \emptyset$.[5]

Artifacts are deliberate products of rational agents. When Smith produces an artifact x, she is supposed to consult the design of x. This seems to be a definitional feature of her action: the design sets apart her action, which is said to be an act of production, from bringing about a state of affairs. For if Smith just brought it about that x exists, but did not refer to anything that might be even roughly described as the design of x, then one might entertain a reasonable doubt whether she actually produced an artifact or even whether her action might be adequately described as an act of production. If you move in a certain planned way, then it is the design of your walking that "decides" that your movements might be classified as, say, a dance, than as a stroll. Moreover, it is usually believed that consulting the design of an artifact increases the prospects for obtaining the purpose for which we produce the artifact. If both Smith and Brown wish to achieve the same purpose y and because of these wishes Smith produces an artifact x_1 and Brown produces an artifact x_2, then if Smith resorts to the design of x_1 and Brown does not resort to the design of x_2, then it is more probable that x_1 makes it easier for Smith to achieve y than that x_2 makes it easier for Brown to achieve y. If both probabilities happen to be equal, then Smith's efforts are likely to be more economical in terms of time, energy, materials, etc., than Brown's efforts.

We produce artifacts referring to their designs. It means that when one produces an artifact x, then either one modifies some object(s) in accordance with the design of x, or, as R. Dipert rightly observed, one deliberately leaves some of x's features unmodified (Dipert 1993: 27-28). In the latter case, the design of x contains the states of affairs contemplated and deliberately left unmodified by the designer(s) of x.

Different kinds of artifacts require different kinds of designs. There are electrical schemes, elevation drawings, musical scores, etc. I will call a design of this kind a *technological design* of an artifact. When I speak about such designs, I will refer to these technological designs that specify the details of ready-to-use artifacts. Thus, so-called manufacturing bills of materials and logistic bills of materials are not technological designs in the sense I use in this paper (cf. Simons and Dement 1996: 268). Even so, the variety of designs is still enormous. Consequently, in order to reduce it a little further I introduce the philosophical notion of design. I claim that for every artifact x, there exists an entity which determines the artifactual features of x. I will call that entity the *philosophical design* (or *design* for short) of an artifact x. Loosely speaking, a design of an artifact is a structure of specimens of the artifact's features. When a designer constructs a design, the result of her efforts, whatever it can be, is representable by some set of sentences from L_A.[6] Every such sentence represents a state of affairs; therefore, a design of an artifact might be identified with a set of states of affairs. However, I will identify designs with join semi-lattices $\langle X, \leq \rangle$ of states of affairs[7] because the respective states of affairs compose the design not separately but they form a single whole. This means that for every pair (and consequently for every k-tuple) of sentences representing two (k) parts of the design, there is a sentence, namely the conjunction of these sentences, that represents the join of these parts.

(4.3$_C$) For every artifact x, there exists a join semi-lattice $\langle X, \leq \rangle$ of states of affairs which is a design of x.

It is here that we can appreciate the rationale for the distinction between sentences and states of affairs. In most cases the technological design of an artifact may be represented by different descriptions (i.e. sets of sentences), but there is no doubt that the designer intended to construct a unique design.

No design specifies all details of its artifact. For example, an elevation drawing might not specify whether an awning above a window is part of a window, or part of a wall, or both. The underdetermination of artifact designs comes in degrees. For some artifacts, such as watches or binoculars, few details of their structure are not determined by their designs. Other artifacts, such as dishes or video performances, are underdetermined to a large degree.

How many designs does an artifact have? At first sight, it seems that the answer is straightforward: Every artifact is bound to have exactly one design. Observe however that an artifact may be a part of another artifact and a design of the latter may not specify all details of the former. A diode is a part of a power supply. The design of the diode that is part of the design of the power supply specifies only two parts of the diode: the anode and the cathode. Still, a more detailed design of the diode, for instance the design you may find in a handbook on general electronics, mentions also a semi-conductor junction between the anode and cathode. Consequently, the diode has at least two designs. Consider also another case. Assume for the sake of an example that organisations are artifacts. The design of the United Nations mentions the Republic of Poland as its part and Warsaw as its capital. Nevertheless, the design does not mention provinces of Poland as parts of the UN. Still, the design of the Republic of Poland, which is determined by the current administrative Polish law, mentions the Lublin province as a part of Poland. Consequently, the Republic of Poland has at least two designs.

I contend that some artifacts possess more than one design and that we should speak about a design of an artifact with respect to a design of another artifact than

[5] Since every sentence from $Purpose(x, y)$ represents some state of affairs, 4.2 entails that for every artifact x, there is an agent y such that $Purpose(x, y) \neq \emptyset$.

[6] Do you need a technological design to produce a design? Yes, if the latter is a result of a routine procedure. No, if the latter is a result of some creative process. If a design is produced according to some design, then the latter is a special kind of artifact. There is no risk for an infinite regress provided that you remember about creative designing.

[7] A poset $\langle X, \leq \rangle$ is a *join semi-lattice* if for every $x, y \in X$, $\exists z \in X\ z = x \vee y$.

about a design of an artifact *simpliciter*. The expression 'x_1 is *a design of* an artifact y_1 *with respect to* a design x_2 of an artifact y_2' will mean 'a design x_2 of an artifact y_2 contains a design x_1 of an artifact y_1' or 'a design x_1 of an artifact y_1 is a part (i.e. sub-design) of a design x_2 of an artifact y_2'. 4.4 captures the precise meaning of these phrases.

(4.4) $\langle X, \leq\rangle$ is a *design of an artifact* x *with respect to* a design $\langle Y, \leq\rangle$ of an artifact y iff $X \preccurlyeq Y$.

(4.5) A design $\langle X, \leq\rangle$ is *less specific than* a design $\langle Y, \leq\rangle$ iff $X \prec Y$.

It can be argued that the production of artifact is a rational action provided that the set of designs associated with a given artifact has its greatest element and its least element with respect to $\preccurlyeq$. The existence of the former guarantees that every artifact is uniquely determined by its design as far as its physical structure is concerned. The existence of the latter guarantees that there is an objective rationale for artifact tokens identification (cf. 4.23 below). Let a set $design_i(x) \subseteq S_A$ be a design of an artifact x and let $\boldsymbol{design}(x) := \{design_i(x)\}$. (Remember that every set $design_i(x)$ is a join semi-lattice.)

(4.6) $\exists X_1, X_2 \in \boldsymbol{design}(x)\ \forall X \in \boldsymbol{design}(x)\ (X_1 \preccurlyeq X \wedge X \preccurlyeq X_2)$.

The most specific design of an artifact x will be called the *full design of* x and the least specific design will be called the *minimal design of* x. The full design of x will be denoted by $Design(x)$ and the minimal design will be denoted by $design_0(x)$. For the sake of simplicity, if x is not an artifact, I assume that $\boldsymbol{design}(x) := \{\emptyset\}$.

Since all products of human activity are finite, therefore all philosophical designs are finite sets as well.

(4.7) $|design_i(x)| < \aleph_0$.

Since designs are join semi-lattices, 4.7 makes it possible to identify designs with complex states of affairs. A design of an artifact x is then the state of affairs $y = \sup_{\leq} design_i(x)$.

A set $design_i(x) \subseteq L_A$ contains the sentences that represent elements of $design_i(x)$; similarly, for $\boldsymbol{design}(x)$ and $Design(x)$.

Both artifacts and non-artifacts may occur in artifact designs, but on pain of infinite regress in artifact designs, I assume that no artifact occurs in its own design.

(4.8$_C$) $x \notin \boldsymbol{O}(Design(x))$.

4.8 does not proscribe designs such as 'A hammer consists of a haft and …', but it proscribes such designs as 'A hammer consists of a hammer and …'

In the domain of technical artifacts, it is of the uttermost importance for the reliability of technical artifacts that the designs are not underdetermined to a large degree. Although we are not in a position to determine all details of our products, we should at least specify what artifacts compose a given artifact. Consequently, it seems that designs created by rational designers should strictly involve at least minimal designs of artifacts occurring in these designs:

(4.9$_C$) If $x \in \boldsymbol{O}(Design(y))$, then $design_0(x) \prec Design(y)$.

For instance, in the Functional Representation framework device components are identified, *inter alia*, by their ports or terminals. A port of a device component x is a part of x at which x comes together with other components in certain ways (c.f. Chandrasekaran 1994: 85; Chandrasekaran and Josephson 2000: 164). The claim that all device components have ports amounts in the four-dimensional ontology to the claim that for every device x, a design of x contains (or at least involves) some design of every x's component.

The purposes of an artifact do not determine uniquely its design since artifacts made according to different designs may serve the same purpose, but it might be argued that the design of an artifact determines uniquely its purposes (as ascribed to it by a community of rational agents).

(4.10$_C$) If $Design(x_1) = Design(x_2)$, then $Purpose(x_1, y) = Purpose(x_2, y)$.

The third element of my conceptual model of artifacts is background knowledge. When Smith designs some artifact, her designing is not a chaotic sequence of independent actions. Her designing forms a relatively compact structure of actions linked together by her conceptual decisions based on some background knowledge. The information she refers to does not determine her action exhaustively, but the more influential impact it exerts, the less accidental the resulting design turns out to be. Similarly, when Brown produces the artifact designed by Smith, Brown is guided by information from some source of information. The "sum" of information from both sources will be called the *background knowledge relevant for* a given artifact. Perhaps the term 'knowledge' might be misleading here since I mean by it an unordered collection of information to which a designer(s) or a manufacturer(s) of an artifact implicitly or explicitly refers. The background knowledge relevant for an artifact x contains not only general theorems about the nature of objects of the same kind as x, but also practical rules of thumb relevant for the production of x. For example, the practical experience of a potter also falls under this broad notion of knowledge. The majority of artifacts we use are designed and manufactured on the ground of vague psychological and sociological observations concerning our desires, fears, preferences, beliefs, etc., but we may generically determine the content of the relevant background knowledge by using labels: mathematics, quantum chemistry, physiology of hearing, etc.

I will represent the background knowledge relevant for an artifact x by a set $Knowledge(x)$ of sentences from L_A.

(4.11$_C$) For every artifact x, $Knowledge(x) \neq \emptyset$.

It seems plausible to assume that the background knowledge is a theory with respect to the consequence operation C. I define an auxiliary extension of C:

(4.12) $C_{K(x)}(X) := C(X \cup Knowledge(x))$.

Of course, our new consequence operation must be consistent (with respect to C). Moreover, since we are interested in communities of rational agents, I stipulate that $Purpose(x, y)$ be $C_{K(x)}$-consistent with $Design(x)$ (i.e. that the set $Purpose(x, y) \cup Design(x)$ be $C_{K(x)}$-consistent).

The background knowledge relevant for an artifact x is determined uniquely by a design of x.

(4.13$_C$) If $Design(x_1)=Design(x_2)$, then $Knowledge(x_1)=Knowledge(x_2)$.

The states of affairs from $Design(x)$ characterise the static features of x, but the set $C_{K(x)}(Design(x))\backslash C_{K(x)}(\emptyset)$ characterise the dynamical features of x. In particular, the latter describe (the patterns of) x's causal interactions with other objects.

Finally, observe that in general the purposes of an artefact do not determine its full design or the respective background knowledge. Usually we may achieve our aims by different means.

The last element of my conceptual model is instructions of use. As a rule, artifacts do not help us in achieving our aims merely by themselves, but we must "set them in motion." Even those more automatic devices, such as mixers or washing machines, require from their users some actions. In addition, more sophisticated artifacts as pieces of music "work" only if their "users" are properly disposed or behave in a special way. Some artifacts, such as household appliances, are accompanied by explicit sets of instructions, others such as books or paintings, are to be used according to some implicit strategies. If you fail to follow the instructions of use for an artifact, you will presumably not achieve the aims for which you make use of that artifact. Obviously, every complete set of instructions for an artifact does not completely characterise all details of the artifact's use.

As in the case of designs, I distinguish a *technological instruction of use* from a *philosophical instruction of use*. The former is usually a sentence in the imperative mood, the latter is the ontic representation of the declarative counterpart of that sentence. The sentence 'Press the power shot button in intervals of at least 5 seconds!' is a technological instruction associated with the state of affairs that some y presses the power shot button in intervals of at least 5 seconds, which is a philosophical instruction of use. I surmise that it is feasible to recast the technological instructions related to an artifact x for an intentional agent y as a set $Use(x, y)\subseteq S_A$. A set $Use(x, y)\subseteq L_A$ will contain the linguistic representations of these states of affairs.

(4.14$_C$) For every human oriented artifact x, there is an intentional agent y such that $Use(x, y)\neq\emptyset$.

Introducing technological instructions of use we usually have two aims. First, they are to guarantee that a user of an artifact and the artifact itself meet certain conditions, i.e. the respective states of affairs in which the user and the artifact occur are among the artifact's philosophical instructions of use. Secondly, the technological instructions of use are to guarantee that the "surroundings" of the artifact are of the prescribed kind. Most artifacts are environment sensitive, that is, they work in accordance with their user's wishes only if they are used in the specific conditions of environment. When one exploits a given artifact, one should guarantee that objects (possibly including other intentional agents) in its neighbourhood have certain features. The respective states of affairs in which these objects occur are also among philosophical instructions of use.[8]

Since I speak about artifacts used by communities of rational agents, therefore it is reasonable to assume that it is the designer(s) who formulates the instructions of use for such artifacts. Sometimes, however, it may happen in the course of time that some users modify these instructions (by deleting or adding a new item) when they notice either that the artifact in question does not achieve one of the aims they ascribe to it or that some instruction of use may be substituted by another instruction if the latter is more easier for them to bring it about. Subsequently, I contend that it is a community of rational agents that eventually ascribes instructions of use to artifacts, but I also contend that it is an designer(s) of an artifact who plays a decisive role in this process.

It is obvious that $Use(x, y)$ is $C_{K(x)}$-consistent with $Purpose(x, y)\cup Design(x)$. The instructions of use must also satisfy the *feasibility constraint* to the effect that a user of an artifact should be able to follow its instructions of use:

(4.15$_C$) If x is an instruction of use for an artifact y with respect to a user z, then z is able to bring it about that x is the case.

The instructions of use for an artifact x are uniquely determined by the design of x and the background knowledge for x, or in face of 4.13, only by the design of x:

(4.16$_C$) If $Design(x_1)=Design(x_2)$, then $Use(x_1, y)=Use(x_2, y)$.

The general idea behind the notion of instruction of use is that if we follow all prescribed commands, then an artifact produced according to its design will help us to achieve the aims for which it was produced (and we are in a position to ascertain that fact if we have access to the relevant background knowledge):

(4.17$_C$) $Purpose(x, y)\subseteq$
$\subseteq C_{K(x)}(Design(x)\cup Use(x, y))\backslash C_{K(x)}(\emptyset)$.

4.17 delimits the purposes a community of rational agents may ascribe to artifacts. 4.17 also shows how the present framework deals with the crucial distinction between proper and improper purposes of artifacts. The former are represented by the set $Purpose(x, y)$ and the latter are represented by the set $C_{K(x)}(Design(x)\cup Use(x, y))\backslash (C_{K(x)}(\emptyset)\cup Purpose(x, y))$.

Now let me briefly reflect on artifacts produced for the sake of other artifacts. Avoiding repetitions, I will emphasise only those points that diverge from my previous remarks on human-oriented artifacts.

Whose purposes does the Zener diode in the power supply of my computer serve? One might answer that it indirectly serves my purposes since it is a part of a part of an artifact I use. Then I would be able to wish, albeit indirectly, the function of the Zener diode in the power supply to be the case. This means that I would be able to

[8] It seems to me that the notion of instruction of use plays here the same role as the notion of mode of deployment in the Functional Representation approach (cf. Chandrasekaran and Josephson 2000: 171).

wish the state of affairs that the Zener diode sets the reference voltage to be the case. By 4.1 if I wished that, I would have to know what it would be for that state of affairs to be the case. This presupposes a substantial part of general knowledge about electrical circuits and the particular knowledge about the electrical schema of the power supply in my computer. However, usually users of artifacts lack both kinds of knowledge.

I claim, thus, that artifact-oriented artifacts serve the purposes of other artifacts "towards which they are directed." The second argument of the function *Purpose*(x, y) ranges now over the same set as the first argument, namely, over the set of artifacts. The Zener diode serves not my purposes but the purposes of the power supply of my computer. What does it mean to be a purpose for an artifact? More perspicuously, what does it mean to have a function (play a role) in an artifact? I claim that artifact functions are states of affairs determined by artifact designs. A Zener diode has a function (plays a role) in a power supply. The function of a Zener diode in a power supply is described by the design of the power supply roughly as follows: a Zener diode sets the reference voltage at x volts. The Zener diode has this function in a power supply since (i) this function is a state of affairs specified by the design of the power supply, (ii) the diode occurs in that state of affairs, and (ii) the relevant design of a diode is less specific than the design of a power supply. Generalising,

(4.18) An artifact x *has a function* y (*plays a role* y) *in* an artifact z iff
- (i) y is a state of affairs from the full design of z,
- (ii) x occurs in y,
- (iii) the minimal design of x is less specific than the full design of z.

Notice that clause (iii) follows from (i) and (ii) because of 4.9.

Let 'PLAYxyz' abbreviate 'An artifact x plays a role y in an artifact z'. Then 4.19 is a formal translation of 4.18.

(4.19) $\mathrm{PLAY}xyz \equiv y\in \mathit{Design}(z) \wedge x\in \boldsymbol{O}(y) \wedge$
$\wedge\ \mathit{design}_0(x)\prec \mathit{Design}(z)$.

Observe that the following claim holds due to 4.8.

(4.20) $\mathrm{PLAY}xz_1y \rightarrow \sim\mathrm{PLAY}yz_1z_2$.

If $z\in \mathit{Purpose}(x, y)$ and y is an intentional agent, then z will be called an *aim of* x (for y). If $z\in \mathit{Purpose}(x, y)$ and y is an artifact, then z will be called a *function of* x (in y). 4.18 entails that if y is an artifact, then $\mathit{Purpose}(x, y) \subseteq \mathit{Design}(y)$. If all purposes of an artifact are its aims, I will say that the artifact is *complete*; otherwise, it will be called *incomplete*. The distinction between complete and incomplete artifacts refines the distinction between human-oriented and artifact-oriented artifacts.

Some incomplete artifacts are produced as tools for producing other artifacts, some are produced as efficient components of other artifacts. Tools form a subset of the set of incomplete artifacts because for every tool there is a rational agent who uses it for some purpose and this purpose engages some other artifact (i.e. some other artifact occurs in that purpose).

I have already observed that incomplete artifacts may possess more than one design. For that reason, the relative notion of design is applicable in its full extent only to those artifacts.

Some incomplete artifacts are designed to work without any assistance from intentional agents. Since even then there are some conditions to be satisfied by an artifact and its environment, I will speak about instructions of use also in such cases. Obviously, such instructions of use may be found in a design of some artifact:

(4.21) If $\mathit{Use}(x, y)\neq\emptyset$, y is an artifact, and $\exists z\in \mathit{Design}(y)$ $x\in \boldsymbol{O}(z)$, then $\mathit{Use}(x, y)\subseteq \mathit{Design}(y)$.

The four-dimensional ontology defines an artifact as a quadruple:

(4.22)
(i) *Artifact*: = <*Purpose*, ***design***, `Knowledge`, *Use*>,
and it represents an artifact as a quadruple:
(ii) `Artifact` := <`Purpose`, ***`design`***, `Knowledge`, `Use`>.

4.22(i) addresses the ontological question and 4.22(ii) addresses the representational question. I observe that in general the sets of sentences from (ii) are not uniquely determined by their ontic counterparts from (i).

Remember that purposes and use are dimensions of artifacts determined by a community of rational agents. Therefore, they might be construed as relative to such community. This relativization is necessary when we believe that the same artifact might be used by two communities. Subsequently, the four dimensional ontology of artifacts relativises artifacts to communities of intentional agents. Strictly speaking, there are no artifacts simpliciter, but an artifact is always an artifact relative to some community. For the sake of simplicity, such relativizations are usually suppressed in this paper.

The four-dimensional ontology of artifacts defines an artifact token as follows.

(4.23) An object x is a *token of an artifact* y=<*Purpose*, ***design***, `Knowledge`, *Use*> iff $\mathit{design}_0(y)\preccurlyeq \boldsymbol{S}(x)$.

This definition neglects other dimensions of artifacts because in general the physical structure of artifact token does not mirror these dimensions. Metaphorically speaking, one might say that artifact tokens do not wear on their sleeves what they are for or how they are used.

4.10, 4.13, and 4.16 entail that if two artifacts (i.e. artifact-types) have the same full design, then they are the same artifact:

(4.24) If $\mathit{Design}(x_1)=\mathit{Design}(x_2)$, then $x_1=x_2$.

The above observations verify the claim to the effect that it is the design of an artifact that plays the most important role in determining the nature of the artifact. The design of an artifact specifies (implicitly or explicitly) what entities are parts of the artifact. Therefore, it seems that by the lights of my account artifacts consist of parts specified by their designs.

(4.25) x is a (proper) *functional* part of y (written: Pxy) iff there is some role that x plays in y.[9]

I will conclude this section with a note on non-artifacts. I will say that an object x *has no purposes* (*use*) with respect to a community X of intentional agents if X does not ascribe x any purpose (instruction of use) for any intentional agent. An object x is a *non-artifact* (relative to a community of rational agents) *in the strict sense* if x has no purposes (in this community), or no design, or its design is not embedded in any background knowledge, or if x has no use (in the community). An object x is a *non-artifact* (relative to a community of rational agents) *in the broad sense* if x has no design (i.e. $\boldsymbol{design}(x)=\{\varnothing\}$). An object x is a *redundant artifact* (relative to a community of rational agents) if x is not a non-artifact in the broad sense and x has no purposes (in this community). An object x is an *unreliable artifact* (relative to a community of rational agents) if x is not a non-artifact in the broad sense, but its design is not embedded in any background knowledge. An object x is an *unusable artifact* (relative to a community of rational agents) if x is not a non-artifact in the broad sense and x has no use (in this community).

Towards Mereology

Now I compare the mereological consequences of the four-dimensional ontology with the principles of the classical mereology. The irreflexivity and asymmetry of the functional parthood are guaranteed by 4.20. What about transitivity? If x is a functional part of y and y is a functional part of z, is x also a functional part of z? By 4.25, this question amounts to the following question: If x has a function f_1 in y and y has a function f_2 in z, is there any function f that x has in z? By 4.18, the answer to this latter question depends on the details of the design of y and of the design of z. However, there is ample evidence that designs do not guarantee the transitivity of the functional parthood. Consider the following counterexample. The memory chip is a functional part of my computer and the computer is a functional part of my university's intranet, but the memory chip is not a functional part of the intranet. The four-dimensional ontology explains why transitivity fails in this case. According to the full design of the computer, the memory chip is a functional part of the computer. According to full the design of the university's intranet, the computer is a functional part of the intranet. Nonetheless, according to none of these designs the memory chip is a functional part of the intranet. The full design of the computer does not contain any details of intranet's connections and the full design of the intranet does not specify all details of the computers connected by the intranet.

To generalise the issue, assume that an artifact x has a function f_1 in an artifact y. By 4.19, it means that

(i) $f_1 \in Design(y) \wedge x \in \boldsymbol{O}(f_1) \wedge design_0(x) \prec Design(y)$.

Assume now that y has a function f_2 in an artifact z. By 4.19, it means that

(ii) $f_2 \in Design(z) \wedge y \in \boldsymbol{O}(f_2) \wedge design_0(y) \prec Design(z)$.

Now if $\boldsymbol{design}(y)=\{Design(y)\}$ (or even if $Design(y) \prec Design(z)$), then there is a state of affairs such that it is a function that x has in z. By the right-most conjunct of (ii), there is a state of affairs $f_1' \in Design(z)$ such that $f_1 \leq f_1'$. Observe that

(iii) $f_1' \in Design(z)$,

(iv) $x \in \boldsymbol{O}(f_1')$ (cf. 2.4),

(v) $design_0(x) \prec Design(z)$.

The conjunction of (iii)-(v) amounts to the claim that x has the function f_3 in z. Concluding, if all artifacts possessed unique designs, then the relation of functional parthood would be transitive.

The Weak Supplementation Principle (WSP) and the Strong Supplementation Principle (SSP) play an important role in the system of the classical mereology (cf. Simons 1987).[10] Given 4.19 and 4.25, it is easy to find a formal countermodel to WSP and SSP. Let $\{s_0\}$ be a design of an artifact x and let $\boldsymbol{O}(s_0)=\{x_0\}$; x_0 is a non-artifact in the broad sense. Let $\{s_0, s_1, s_0 \vee s_1\}$ be a design of an artifact y ($x \neq y$) and let $\boldsymbol{O}(s_1)=\{x\}$ and $\boldsymbol{O}(s_0 \vee s_1)=\{x, x_0\}$. Then P$xy$, but if P$zy$, then IP$zx$.

Nonetheless, it is much more laborious to find real artifacts that falsify WSP. First, consider a general case. Let x be an artifact such that the full design of x does not specify its colour. Let y be an artifact such that the full design of y is identical with the full design of x except for the colour specification: y is designed to be painted red. Then x is a proper functional part of y, but every functional part of x overlaps some functional part of y.[11] Consider also two particular cases. The civil law in Poland requires that every article in a shop should be labelled with a price. According to that law, the only functional part of a price label is an inscription of the price, but this inscription is not identical with the label with the inscription on it. Another example might be such aleatoric piece of music that has a fixed core, but whose other parts are not determined by its musical score. This score specifies that (i) the core is the only functional part of the piece of music and that (ii) the latter is not identical with the former.

Although the four-dimensional ontology does not entail SSP, it guarantees the extensionality of artifacts with respect to their functional parts and the functions of those parts:

(5.1) If $\exists x\,(Pxy_1 \vee Pxy_2)$, then
$[\forall x, z\,(PLAYxzy_1 \equiv PLAYxzy_2) \rightarrow y_1=y_2]$.

5.1 follows from 2.5, 4.18, and 4.24.

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[9] x is an *improper functional* part of y (written: IPxy) iff x is a proper functional part of y or $x=y$.

[10] (WSP) If x is a proper part of y, then $\exists z$ (z is a proper part of y and z does not overlap x).
(SSP) If x is not a part of y, then $\exists z$ (z is a part of x and z does not overlap y).
SSP entails WSP since the relation of parthood is asymmetric.

[11] For an argument against classifying properties of objects as their parts, see (Denkel 1996: 38-39).

Admittedly, 5.1 does not entail the standard extensionality principle for the functional parthood:

(5.2*) $\exists x\,(Pxy_1 \vee Pxy_2) \rightarrow [\forall x\,(Pxy_1 \equiv Pxy_2) \rightarrow y_1=y_2]$.

The reason why 5.2 is not universally valid is the multi-functionality of artifacts. Assume that an artifact y_1 consists of artifacts x_1 and x_2, and that x_1 plays in y_1 a role f_1 and that x_2 plays in y_1 a role f_2. Assume further that an artifact $y_2 \neq y_1$ consists of the same artifacts, but (due to the difference the in spatial configuration) x_1 plays in y_2 a role f_3 and x_2 plays in y_2 a role f_4. We get a model in which all axioms but 5.2 are satisfied.

5.3 shows that the mereological axiom of general sum is false for functional parts, provided that there are at least two complete artifacts.

(5.3) If there are at least two complete artifacts, there are at least two artifacts such that
  (i) one is not a functional part of the other,
  (ii) there is no artifact of which they both are functional parts.

If we restrict our attention to some restricted sub-domains of artifacts, other principles for the functional parthood might turn out universally valid. Let me mention here one possibility.

(5.4) $PLAYxf_1y \wedge PLAYxf_2y \rightarrow f_1=f_2$.

This axiom seems to be an innocuous simplification of the notion of artifact function. It guarantees that a design of an artifact is not over-detailed.

5.1 and 5.4 entail a strong identity criterion for non-atomic artifacts:

(5.5) $PLAYxzy_1 \wedge PLAYxzy_2 \rightarrow y_1=y_2$.[12]

Nonetheless, the functionalist mereology with 5.4 is still an exceptionally weak system. Astonishingly enough, it appears that the binary relation '*x* is a functional part of *y*' is an inadequate formal tool for modelling the domain of artifacts. If you know that *x* is a functional part of *y*, you do not know what function *x* has in *y*. Since the mereological structure of artifacts might be described in more detail by the ternary relation '*x* has a function *y* in *z*' (PLAY*xyz*), therefore I conjecture that we should reconsider our natural inclination to conceptualising artifact parts of in terms of binary relations. [13]

Evaluation

In addition to a methodology for ontological investigations of artifacts, Vermaas and Houkes provided also a set of desiderata for any adequate theory of artifact functions. Now I will scrutinise my ontology against these constraints.

D1. *Proper versus accidental*: A theory of functions should distinguish between the proper and accidental function(s) of an artefact. Proper functions can typically be understood as functions ascribed standardly to the artefact, whereas accidental functions are ascribed only occasionally.

D2. *Malfunction*: A theory of functions should admit an ascription of proper functions to malfunctioning artefacts, i.e. artefacts that are unable to perform their functions.

D3. *Physical structure*: A theory of functions should entail that for every function there exist structural conditions sufficient for its performance. Moreover, if a theory ascribes a function to an artifact, it should provide partial justification for the belief that the physical structure of the artifact satisfies such conditions.

D4. *Novelty*: A theory of functions should admit an ascription of proper functions to innovative or atypical artefacts. (Vermaas and Houkes 2003: 265-266)

I initially observe that the meaning of the word 'function' as used by Vermaas and Houkes corresponds to the meaning of the word 'purpose' as I use it. Thus, their functions are either my aims or functions. They do not account for the possibility that an artifact may possess different functions for different users.

The four-dimensional ontology of artifacts satisfies the first constraint. If *y* is an intentional agent, then the proper functions of an artifact *x* are gathered in the set *Purpose*(*x*, *y*). In other words, my aims are proper functions in the sense of Vermaas and Houkes. Their accidental functions are represented by the set $C_{K(x)}(\mathtt{design}_i(x) \cup \mathtt{Use}(x, y)) \setminus (C_{K(x)}(\varnothing) \cup \mathtt{Purpose}(x, y))$. All my functions are bound to be proper functions in the sense of Vermaas and Houkes.

As for the second constraint, the ontology makes it possible to discriminate four kinds of malfunctioning artifacts: misinterpreted, misdesigned, misused, and malstructured artifacts. An artifact *x* is *misinterpreted relative to* an intentional agent *y* if given *x*'s design $design_i$ (*x*) and instructions of use *Use*(*x*, *y*), the community of intentional agents ascribes *x* such a purpose from *Purpose* (*x*, *y*) that constraint 4.17 is not satisfied for *Purpose*(*x*, *y*), $design_i(x)$, and *Use*(*x*, *y*). An artifact *x* is *misdesigned relative to* an intentional agent *y* if given some purposes *X* of *y* communicated by the community of intentional agents to an artifact designer, she invents a design $design_i(x)$ of *x* and accompanies it with a set of instructions of use *Use*(*x*, *y*) such that constraint 4.17 is not satisfied for *Purpose*(*x*, *y*)=*X*, $design_i(x)$, and *Use*(*x*, *y*). A token *x* of an artifact *y* is *misused by* an intentional agent *z* if using *x*, *z* does not follow *y*'s instructions of use (for *z*). A token *x* of an artifact *y* is *malstructured* if at least one of the states of affairs in which *x* actually occurs is not compossible with some state of affairs specified by the full design of *y*.

Observe that since 4.17 has been introduced as a rationality constraint, there are no misinterpreted or misdesigned artifacts. Still, the account makes room for misused or malstructured artifacts.

As for the third constraint, the sufficient conditions relevant for achieving the purposes ascribed to an artifact are guaranteed by its design. 4.17 entails that the design

[12] The role of identity criteria in knowledge engineering is explained in (Guarino and Welty 2001).

[13] A similar conjecture is expressed in (Salustri and Lockledge 1999). Salustri and Lockledge suggest employing the ternary relation '*x* is a part of *y* with respect to a set *Z* of characteristic features of *x* and *y*.'

together with the instructions of use form a sufficient condition for these purposes to be achieved. The belief that an artifact x may serve purposes represented by the set $C_{K(x)}$ (`Design(x)`$\cup$`Use(x, y)` $\setminus$ $C_{K(x)}(\emptyset)$ is justified by the relevant background knowledge `Knowledge(x)`.

As for the fourth constraint, since the ontology does not mention design processes at all, it trivially allows for innovative design processes and innovative artifacts. Moreover, since I contended that purposes are ascribed to artifacts by communities of intentional agents, it is possible that the respective community will ascribe to an artifact a purpose that was not intended by its designer(s). In this sense, the ontology admits an ascription of proper functions to innovative artifacts.

Since according to Vermaas and Houkes no standard etiological theory of function satisfies their all constraints, I conclude that the four-dimensional ontology sketched in this paper is superior to all such theories as applied to the realm of artifacts.

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