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Discussion

The functional bias of the dual nature of technical artefacts program

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ABSTRACT

In 2006, in a special issue of this journal, several authors explored what they called the dual nature of artefacts. The core idea is simple, but attractive: to make sense of an artefact, one needs to consider both its *physical* nature—its being a material object—and its *intentional* nature—its being an entity designed to further human ends and needs. The authors construe the intentional component quite narrowly, though: it just refers to the artefact's function, its being a means to realize a certain practical end. Although such strong focus on functions is quite natural (and quite common in the analytic literature on artefacts), I argue in this paper that an artefact's intentional nature is not exhausted by functional considerations. Many *non-functional* properties of artefacts—such as their marketability and ease of manufacture—testify to the intentions of their users/designers; and I show that if these sorts of considerations are included, one gets much more satisfactory explanations of artefacts, their design, and normativity.

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1. Introduction

In a special issue of this journal dedicated to the so-called dual nature of artefacts, guest editors Kroes and Meijers summarize the baseline of their program (and that of the different contributors) as follows:

> [...] technical artefacts can be said to have a dual nature: they are (i) designed physical structures, which realize (ii) functions, which refer to human intentionality. [...] In so far as technical artefacts are physical structures they fit into the physical conception of the world; in so far as they have intentionality-related functions, they fit into the intentional conception. (Kroes & Meijers, 2006, p. 2)

Artifacts, thus, are physical entities, subject to the laws of nature, but what makes them different from stones and clouds—that is, what makes them artefacts—is the fact that they are intentionally produced and used by human beings to realize certain goals. Unlike stones and clouds, artefacts have a clear purpose, a function, a certain "forness". To miss this property, is just to miss what it means to be an artefact. Hence, a description of an artefact that doesn't address both its physical and intentional nature would be (hopelessly) incomplete.

The fact that artefacts can be characterized in terms of purposes isn't really new (see, e.g., Simon, 1969); neither is the idea that artefacts are explainable in terms of both their physics and their design (see e.g., the stance theory of Dennett (1978, 1989)).[1] But then again, for the contributors to the special issue, the dual nature idea is not so much a final thesis as a hypothesis for further research; the authors put it to work to give novel and detailed accounts of artefact ontology, normativity and explanation. They discuss how the physical and intentional natures connect (Vermaas & Houkes, 2006; Houkes & Meijers, 2006), how they come about through design (de Ridder, 2006), how the notion of proper function is couched within proper usage (Houkes, 2006), how proper function and usage are partly determined by social processes (Scheele, 2006), how the notion of proper function links to evaluative and normative judgments concerning malfunction and correct usage (Franssen, 2006).

However, while the range of topics the authors cover is quite wide, I think that much remains unexplored. This isn't so much due to limitations of space as to an unfortunate, one-sided interpretation of the dual nature thesis.

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[1] In fact, one already finds traces in Aristotle of the views expressed by Simon, Dennett, and the dual nature theorists.

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Roughly, the problem is this. Once the distinction between structure and intent is made, the dual nature theorists too quickly interpret intent in terms of function, in terms of what an artefact is for, in terms of the purpose the object is supposed to serve. They do not consider the possibility that other, *non-functional* artefactual properties might testify to the ends humans have. This pronounced preoccupation with function—rather the rule than the exception in the analytic literature concerning artefacts[2]—cuts off an area which it is the purpose of this paper to explore. Since nothing in the dual nature thesis itself asks for the particular choice the dual nature theorists make, my argument doesn't undermine but rather complements their work.

To give a flavor of what I am after, consider a simple example. Microsoft Word, OpenOffice Writer and LaTeX are more or less functionally equivalent: they are all packages for producing text documents. Nevertheless, they *do* differ substantially. The former two, for one thing, are WYSIWYG ("What You See Is What You Get"), they handle text composition and typesetting simultaneously. LaTeX on the other hand, divorces writing from typesetting; the user "programs" her text in a simple text editor, LaTeX only afterwards produces a document with the required layout. Defenders of both types of packages think theirs is the easiest to use, Microsoft Word and OpenOffice Writer because of their intuitive and preprogrammed modules, LaTeX because of its highly adjustable programming code. The fact that OpenOffice Writer and LaTeX are open source isn't explainable just in functional terms either; it is a property that testifies to the commitment of a community of users to the principles of free and open software. Conversely, Microsoft Word is closed source, due to Microsoft's focus on the protection of its trade secrets.

These kinds of features, I will argue, relate to the intentional nature of artefacts, but don't figure in the accounts of the dual nature theorists. And I will argue that this is a mistake: form doesn't necessarily follow function, a fact which any full explanation of artefacts needs to accommodate.

My argument proceeds as follows. In the next section, I detail the approach taken by the dual nature theorists, and point out the origins of their strong functional bias. Next, I discuss the different non-functional, but intentional features of artefacts that surface during artefact usage (Section 3) and artefact design (Section 4). Finally, I explain how this bears on the dual nature thesis (Section 5) and end with some concluding remarks (Section 6).

2. The dual nature program's functional bias

In this section I uncover the functional bias in the dual nature program, going through some of its core ideas in the meantime. To that end, consider again the quote of Kroes and Meijers with which I opened the introduction,[3] and note the particular phrasing of (ii). Kroes and Meijers do not write that artefacts have intentionality-related properties, among which we may find—as a sort of contingent fact, and next to other subclasses—the (admittedly important) subclass of functional properties. Rather, the second nature of artefacts (viz. the intentional) is fully characterized in terms of functions [p. 2]: 'in so far as technical artefacts have [...] functions, they fit into the intentional conception.' Likewise, in the remainder of their paper, when the intentional nature of artefacts is discussed, the guest editors let the word "intentional" almost systematically follow by a bracketed "functional", as if the terms were synonyms.

The same applies to the other papers in the special issue. Perhaps the strongest expression of the idea that an artefact's intentional nature is *exhausted* by functional considerations is found in Kroes' contribution: 'a *complete* description of a technical artefact involves a description of *both* functional and structural features' (Kroes, 2006, p. 137, italics added). Other contributors are less explicit, though the link between intention and function implied throughout is remarkably strong. Jeroen de Ridder (2006) argues that what artefact explanations need to explain, is how an artefact's physical make-up enables it to fulfill the behavior associated with its *function*. Houkes and Meijers (2006), in turn, discuss the ontological ramifications of this enabling relation: a proper ontology of artefacts needs to accommodate for the—according to the authors, two-way—interaction of the artefact's material basis and its *function*.

In another paper, the argument from intention to function is more indirect, but just as exclusive. Franssen (2006) is interested in evaluative judgments, like "this is a good drill". Such expressions, Franssen explains, typically do not apply to the realm of nature. It doesn't make much sense to say that a stone is good, except if it is used by a human to promote a practical end (say, to crack a nut). Put differently, evaluative judgments are credible in as far they apply to the sphere of human intentionality. The functional twist, now, is that Franssen *defines* the goodness of a certain artefact in terms of its capacity to realize its functional goal. That an object *x* is a good drill, gives us—at least in case we have some drilling needs to be satisfied—a normative reason to use *x*. Hence, an artefact's goodness simply *is* its instrumental value, its value of being a means to an end.[4]

To be sure, I do not deny the instrumental utility of artefacts. So I will not argue that Franssen's analysis (or that of other dual nature theorists) overlooks an important set of non-instrumental artefacts, such as pieces of art, unintended by-products of human activity (footprints, debris), undesirable distortions produced by computers (e.g. unexplainable patterns in digital imagery) or by measurement instruments (e.g. unexplainable values in scientific experiments); Franssen's account is devised to explain *technical* artefacts (not art nor debris), thus it should be assessed accordingly. Instead, I will show that the instrumental utility of a technical artefact on many a occasion is much wider than its functional goal; its function is just one of the many properties testifying to the purposiveness of its designers and/or of its (community of) users. Applied to the overall dual nature thesis: the interaction between an artefact's structure and function is *just one of the many* interactions between an artefact's material basis and human mental attitudes. A *complete* description of an artefact must accommodate this fact.

Actually, I am not the first to observe the strong focus on functions in the special issue on the dual nature thesis.[5] In a recent paper, for instance, Schyfter (2009) criticizes the fact that the dual nature theorists deploy function as their privileged analytic axis. Surprisingly, though, Schyfter's criticism is not so much that function is the wrong kind of analytic axis, he rather argues that dual nature theorists insufficiently address the sociality of technological functions. His aim, then, is to problematize function as a 'sociotechnical phenomenon embedded within a dense milieu of social practices' (*ibid.*, p. 103).

[2] See e.g., (Dennett, 1978, 1989, 1990), (McLaughlin, 2001), and Lynne Rudder Baker's ontology of artefacts (Baker, 2004).

[3] Almost identical to it is the following excerpt from another article in the bundle: 'artefacts [are] objects with (i) structural (that is, geometric, physical, chemical) characteristics and (ii) functional characteristics which have an intrinsic relation to mental attitudes and intentional actions' (Houkes & Meijers, 2006).

[4] Here is some textual evidence: 'In such cases [i.e. when saying that something is a good drill or a good pump] there is no vagueness at all concerning what the something is that there would be reason to do; it is *using* them.' (Franssen, 2006, p. 46, emphasis in the original)

[5] Kroes and Meijers, in their introduction to the volume (p. 2), do in fact admit it themselves: 'The various contributions to this special issue mainly approach the problem of how to conceptualize the dual nature of technical artefacts via the concept of technical function.'

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As such, Schyfter remains well within the analytic axis of the dual nature program; granted, he details its social presuppositions, but doesn't consider adding a set of new axes. That, now, will be my strategy.

3. Intentional features related to artefact usage

As said, I do not deny the instrumental utility of artefacts. I agree that the use of artefacts typically acts as a means to the promotion of practical ends. So indeed, to a certain extent Franssen is right: an artefact is good, in as far as the realization of its functional goal fulfills our (current) needs. The problem, however, is that such statements invoke a form of instrumental reasoning that simplifies matters too much. And because of this, some interesting intent-related features of artefacts remain hidden—or so I will argue in this section.

The kind of means-end inference implied by Franssen (*inter alia*) can be represented as follows:

S wants to bring about *A*.
Performing *B* brings about *A*.
Therefore *S* performs *B*.

It is the sort of basic inference (most notably) discussed by von Wright in his classic paper *Practical inference* (1963a).[6] It might (but obviously need not) involve artefacts, in particular, when the means clause "performing *B*" stands for operating an artefact *x*. The inference is compelling in as far as performing *B* indeed is a means to *A*, or in case of artefact usage, in as far as using *x* is a means to *A*—that is, in as far as *x*'s functional goal is to bring about *A* and working properly. Hence, in this simple scenario, the *forness* of *x* directly mirrors the *intention* to *A*.

Usually, however, instances of means-ends reasoning are slightly more complicated. At least two important qualifications are relevant here. First, there is the possibility of alternative means to carry out an intention *A*, and second, there is the possibility that performing *B* causes certain undesirable side-effects (see e.g., Bratman, 1987; Walton, 1990). Indeed, in real-life we typically have more than one option available for producing output *A*; and indeed, on many a occasion we must deliberate on conflicts between our performing *B* and the other ends we pursue. So the following scheme would be more accurate:

S wants to bring about *A*.
Performing either B_0, B_1, ... or B_n brings about *A*.
Performing B_i is more acceptable than not bringing about *A*.
Therefore *S* performs B_i.

Suppose now that performing B_0 corresponds to operating artefact x_0, performing B_1 to operating artefact x_1, and so forth. *S* could choose to operate any artefact from the set of functionally equivalent artefacts $\{x_0, \ldots, x_n\}$. For instance, if *S* wants to prepare an electronic document, she would have several options: she might use, among others, Microsoft Word or OpenOffice Writer (or some LaTeX suite, but let's not complicate matters too much). On the basis of what could she make a choice? Let us consider some possibilities.

First of all, it could be that, despite their functional equivalence, Microsoft Word and OpenOffice Writer differ with respect to some performance criterion, that is, one package might simply be better in performing the function of document preparation. Word or Writer might be more reliable (e.g. crash less), for example, or consume less computational resources. Hence, the goodness of either package would be determined not—like Franssen proposes—just in terms of the software's capacity to assist in document preparation (for that is a capacity both packages have), but *relationally*, in terms of how effective and efficient they are at doing so. Such differences in performance are no coincidence; they reflect the *intent* of designers to distinguish themselves (or better, their produce) from competitors and/or what users value in word processing tools. Such line of reasoning, moreover, allows for a contextualization of instrumental goodness. Even though a well-functioning copy of Microsoft Word 1.0 (developed in 1983) would still be a good word processor on Franssen's score (it is still a means to prepare documents, after all), it would be a bad one on my account, since it doesn't meet a set of performance requirements that are standard today.

The question of course is whether these performance characteristics are of the sort I was seeking. That is, are performance characteristics really *non-functional* intent-related features? It depends on the level of detail one thinks a function description should contain. If one thinks that OpenOffice Writer 3.0 has the function of preparing electronic documents *full stop*, performance characteristics definitely fit the bill; if one, on the other hand, favors more elaborate function descriptions—e.g., OpenOffice Writer 3.0's function is to prepare electronic documents while using a maximum of 128MB RAM—talk of functions might suffice after all. To me the first approach seems the most commonsensical. Typically we assign functions in accordance with broad functional types;[7] so even after a century of radical (sometimes revolutionary) innovations, cars have remained cars, television sets have remained television sets. Older versions (of cars, television sets) were perhaps inferior with respect to performance, but not different qua function.

Even if one disagrees with this line of argument, performance isn't the only difference-maker. Given the functional equivalence of two alternatives, a user could choose the alternative that is most attractive aesthetically; that is most easy to use; that affirms the user's status or personality; that is compatible with the rest of the user's toolkit (OpenOffice Writer can open .doc-files, for instance, but Microsoft Word cannot open Writer's .odf-files); that is cheap (price being a performance characteristic of sorts); that can be swiftly personalized; that conforms to fair trade or open source standards; and so forth. Such characteristics are marks of the intentional, though not of the functional.

Let's return to our means-end inference. As said, it is not just that there are several *alternatives* to the effect of *A*, typically an agent *S* pursues more goals than just *A*—hence the *side-effects* clause, which states that effects produced by performing *B* shouldn't cancel out the desirability of *A*. This premise too connects to a set of features neglected by the dual nature theorists. Consider the following example.

In the 1920s, a certain Dr Geyser developed the so-called Tricho System (Bookchin, 1962; Caufield, 1989). Its function was to remove superfluous hair; to that effect, clients would receive a

[6] Here is von Wright's original (which actually surfaces literally in (Kroes, 2006)):
A wants to make the hut habitable.
Unless *A* heats the hut, it will not become habitable.
Therefore *A* must heat the hut.
In his *Varieties of Goodness* (1963b), von Wright considers how such reasoning bears on the instrumental goodness of artefacts—a discussion which neatly parallels that of Franssen (and that of (Hilpinen, 2004)).

[7] This is in fact in accordance with the ontological discussion in (Houkes & Meijers, 2006). The authors remark there that functional types are multiple realizable in material structures or systems. If we, however, would narrow down functional types, including more and more (material) details (e.g. regarding performance, memory usage), such multiple realizability wouldn't hold any more; the functional type would in fact become complete as a description of material implementation, hence realizable in only one unique way.

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four-minute dose of x-rays directly to the face, often once a week for several months. The treatment (evidently) was effective. But it also caused radio-dermatitis, basal cell carcinoma, and other unsavory defects (Lapidus, 1976). So the Tricho System realized its functional goal indeed, though at too large a cost. In the 1940s, the device was officially forbidden by the FDA.

It appears, thus, that we expect artefacts to do certain things (perform their function), but also to *not* do certain things (to interfere with other entities, such as other artefacts, humans, or the environment). Exemplary are considerations of safety, environmental soundness, and non-interference standards regarding broadcasting devices.

Once again, one could try to argue that such features are, at bottom, functional. That, say, the characterization of a contemporary razor is incomplete if no reference is made to its safety, its not causing any ailments of skin. On this account, however, the Tricho System and contemporary razors would have different functions—if not, the Tricho System has a function it cannot perform, namely safe hair removal—each being good at performing its own particular function. Being both effective, it is hard to see on what grounds we could claim one to be better than the other.

Furthermore, apart from not causing cancer, there is a limitless amount of things an electric shaver should not do: it should not make the noise of an airplane, it should not electrocute its user, it should not teleport the things it is in contact with, and so forth. Such infinite conjunctions of don'ts would make functional descriptions impractical, and worse, highly uninformative. My suggestion, thus, is not to inflate the notion of function, and keep it apart from the other considerations I have discussed.

Let me take stock. An artefact has two natures, dual nature theorists argue: it is (i) a physical object that (ii) realizes a function, which refers to the intentionality of human agents. Such characterization, I have argued, may work for contexts in which there is available only one tool (no alternatives), and in which agents have no other desires than the realization of the artefact's functional goal (no side-effects). In other words, the analysis may work for highly idealized contexts, but fails to accommodate contemporary settings, in which artefacts are more than just function-bearers, and in which a multitude of artefacts compete each other and interfere with many of the things we cherish. The goodness of an artefact connects indeed to its functioning properly, but to say that a razor is good, may also mean that it is good with respect to safety (or to compatibility, recyclability, durability, aesthetics and whatnot), that is, it may refer to *non-functional* traits that are of significant value to humans. In short: a razor is (i) a physical object that (ii) has several properties (*among which* its function) testifying to human intentionality.

4. Intentional features related to artefact design

Thus far I have been concerned with artefact usage, with how artefacts bear the marks of the goals users have. A substantial amount of papers in the special issue, however, discusses the dual nature thesis in relation to design. And here again, the intentional is construed primarily in terms of function. For example, here is what Kroes writes:

> Engineers [...] assume that there is an intimate relationship between the function and structure of technical artefacts and they reason from functional properties to structural ones and vice versa. [...] The use of structural and functional properties for the description of technical artefacts is *de facto* indispensable for engineering practice. (Kroes, 2006, pp. 137–139)

In a similar vein, Vermaas and Houkes say that expert designing consists of two things: developing use plans for new artefacts (the intentional part), and determining a physical structure for these artefacts (the physical part), making them suitable to perform their *function* (Vermaas & Houkes, 2006; Vermaas, 2006). As such, 'designers serve their clients as users', by providing for artefacts and 'use plans by which users can attain their goals' (Vermaas, 2006, p. 65). The connection between using and designing, then, is simply that of designers assisting users to attain new or existing goals (see also, Houkes & Vermaas, forthcoming, p. 28 of ms.).

Just in light of the criticism I leveled in the previous section, these views already lose much of their intuitive appeal. If it is true that designers assist users in the attainment of their goals, and users have more than just "functional goals" (as the previous section showed), then, by consequence, it cannot be the case that designers design for function only. But the problem is much deeper: the view of Houkes and Vermaas (*inter alia*) rests on the (obviously?) false assumption that a designer's primary interest is to assist in the realization of her customer's practical goals. A prototypical engineer isn't that altruistic, I guess. Her primary interest most likely lies elsewhere: she wishes to generate some kind of revenues, or more generally, to realize the goals specified in the business model she is working by. And it's not the case that such can be achieved only by serving the interests of her clientèle—as the following three examples show.

First, consider a case study presented by Corbett, Dooner, Meleka, and Pym, (1991). It concerns the design of simple scales, used in the retail business. In 1983, W&T Avery Ltd. introduced the Avery 1770 (see Fig. 1, left), a scale that soon could be seen in shops throughout the UK. Although one expected world market volumes to grow, the company also expected competition to increase. Therefore it immediately started to redesign the 1770, explicitly bearing ease of manufacture in mind. The effort led in 1986 to a new scale, the A600 (see Fig. 1, right).

The Avery 1770 and the A600 are *functionally equivalent*, though their design differs substantially. The A600's particular layout links directly to the *intention* of its designers to come up not so much with a new function (for the artefact's function was already fixed with the Avery 1770), as with an easier design in terms of manufacture.

The Avery 1770 was redesigned according to two principles. First, the configuration was made such that it allowed for a so-called layered assembly procedure, meaning that all components are added to the base in only one direction, viz. vertically down (see Fig. 2). Because of such assembly procedure, the machinery in the production line takes up less space, meaning that a smaller work area is needed. Second, and more importantly, the amount of components was reduced (see Fig. 2). This, in turn, reduced assembly time and furthermore brought along the following benefits (from Corbett et al., 1991): (i) fewer bought-in parts reduced the operational burden on the purchasing department with corresponding cost reduction; (ii) bank charges were reduced as a result of fewer transactions by the purchasing department; (iii) inventory was also reduced, resulting in a reduction in storage space and part transport within the plant; (iv) the production control's task was much eased, as was the risk of late delivery; (v) with fewer parts, the risk of deviation was proportionately reduced, thus enhancing quality assurance; (vi) with less assembly work to do, the assembly task could be conducted in a smaller work area; (vii) even manual assembly operation requires some machine aids, with fewer assembly operations, the cost of such machine aids were reduced correspondingly; and (viii) it became easier to justify capital investment in automated assembly with fewer assembly tasks to be undertaken.

Design for manufacture, thus, seems to have considerable benefits, which are more to the concern of the manufacturer than being motivated by a desire to help clients realize their goals. It is a common objective for manufacturers: cutting costs through design to

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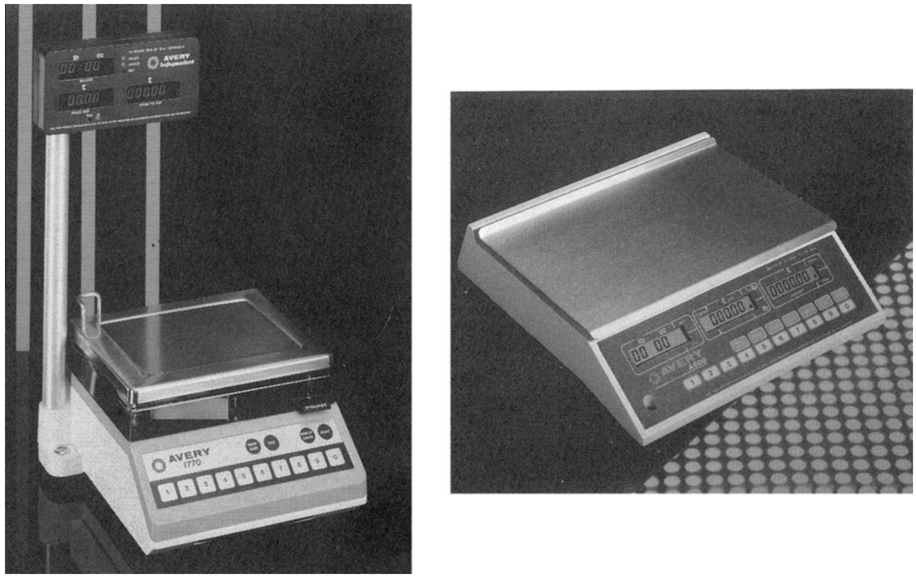

Fig. 1. The Avery 1770 (left) and the Avery A600 (right), redesigned for ease of manufacture. (reprinted courtesy of Pearson Education Limited)

keep ahead of competitors and to boost differences between production cost and retail price. Such *non-functional* design intentions are manifest in the physical structure of the A600 (its consisting of 4 components rather than 8, its layered make-up). Hence, to repeat a by now familiar theme: the intentional exceeds the functional.

The second example concerns design for recoverability. Recovering discarded goods has become quite common nowadays, and, in as far as consumers and/or legislation care for the environment, recoverability is an issue already covered by the notion of interference (viz. with the environment), as discussed in the previous section on artefact usage. Additionally, however, recoverability may offer business opportunities that allow companies to generate profits apart from those generated through mere client satisfaction. This certainly holds when governments discourage mere dumping (e.g. by means of waste taxes) and secondary markets for recovered materials are available.

To learn how to design for disassembly, recycling, and reuse, BMW for example set up a pilot recycling plant in Landshut in the late eighties (Siuru, 1990). In the factory engineers examined techniques to disassemble[8] cars and to recover parts and raw materials. Moreover, they registered the bottlenecks in the disassembly process, information that was used later for the design of future generations of BMW automobiles. These efforts led to the following new design requirements (Penev, 1996): (i) The number of materials used in a car should be limited as much as possible; (ii) composite elements should be avoided; (iii) the number of non-reversible joints should be reduced where possible; (iv) parts and materials should be marked to allow easy identification during disassembly; and (v) only recyclable plastics should be used.

These requirements were implemented to make discarded BMW's profitable; the disassembly time was reduced, materials could be recycled and reused, and since they could be disassembled non-destructively,[9] components could be sold as spare parts. The revenues from such operations were considered in the total production costs; design for recovery thus became part of a larger strategy aimed at realizing the company's business objectives.

Once again, then, we have found evidence that an artefact's physical make-up may refer to intentions other than those implied by its function. A BMW has *reversible* joints (as opposed to joints *simpliciter*), not to make it suitable for driving (that's something non-reversible joints can do just as well), but to facilitate the disassembly process (with as primary beneficiary its manufacturer).

My third and final example is taken from software development. Yourden (1996) estimates that the original release of Windows 95 contained over 13,000 defects that Microsoft decided to solve only after the product's release. Why? Because it rewards to be the first on the market—for the sooner a company can present a first-of-a-kind product, the more it can sell before it has to share the market with competitors—even if this compromises quality. So instead of letting products pass all the quality tests required for bringing them to perfection, software developers design software that is good enough, fixing only those defects that users will most likely find (unacceptable), and deferring refinements to later upgrades. In fact, the best quality tests are often those performed by a product's intended users. Bringing something on the market early, might be rewarding in that sense too; users can do the testing for you, for free (in case of software, this works only to the extent of course that users are willing to send reports regarding the bugs they encounter).

Now, the bugs in Windows 95 have nothing to do with Microsoft's intention to devise a function-bearer serving some practical purpose (viz. operating a PC), quite on the contrary; it is rather a property indicative of Microsoft's ambition to be a market innovator, rather than a market follower. Put differently, Microsoft has goals of its own—goals that do not necessarily align with those of its customers—and such purposiveness is materialized in the artefacts the company produces.

5. The significance of non-functional properties

One strategy to undermine my argument is to downplay the significance of the non-functional intent-related properties I

[8] Disassembly here means a systematic removal of the desired parts form an assembly, with the condition that the disassembly process (as opposed to dismantling) does not result in any damage to the parts (Brennan, Gupta, & Taleb, 1994).

[9] Design for *non*-disassembly might also promote recoverability. Disassembly and dismantling of audio equipment, telecommunication products, car stereos and the like, is a costly operation. However, one can design them in such a way that they, once discarded, can be processed as a whole. Ram, Deckers, & Stevcels (1998), for instance, discuss design for disassembly in the consumer electronics industry. In their example, mechanical processing of electronic equipment results in material fractions which are suitable for further processing in copper smelters, aluminum smelters, incinerators, and so forth.

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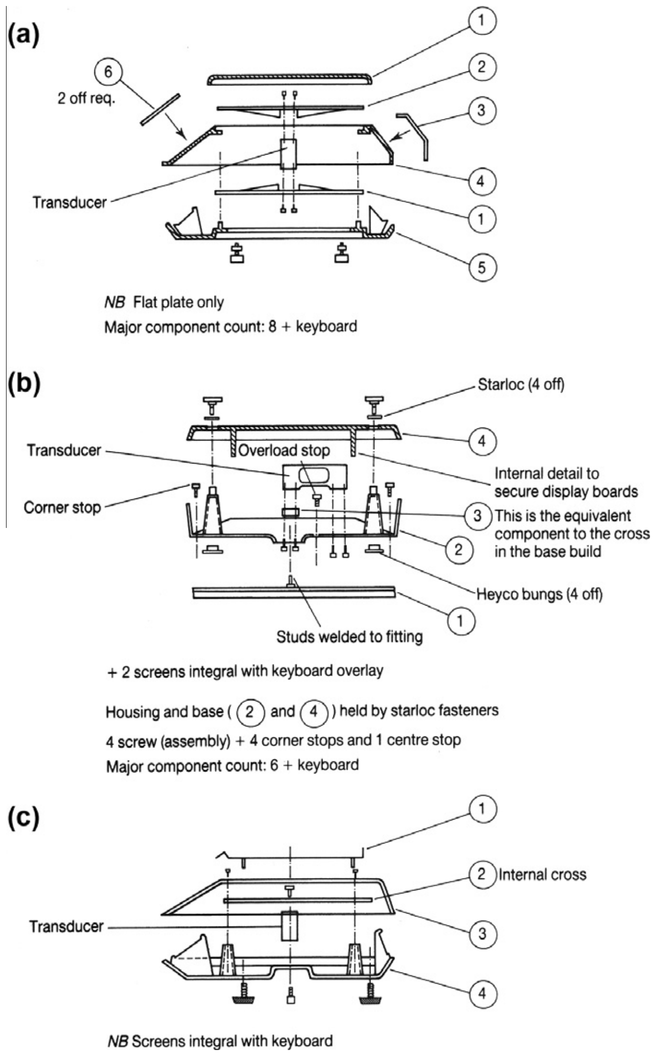

Fig. 2. Three options for the redesign of the Avery 1770. Option (a) requires most components, and moreover doesn't allow for layered assembly (components 3 and 6 should be added from a different angle than the other components). The winning option (Option (c)) has only 4 major components, and can be assembled one-directionally. (reprinted courtesy of Pearson Education Limited)

introduced. One could, for instance, follow an argument by Hilpinen (2004) and discern between properties relevant to an artefact's function and those simply irrelevant to it. Hilpinen calls the former the significant or good-making properties of the artefact. For example, the weight of a hammer is one of its significant features, but its color is usually not. If this is right, the fact that the dual nature theorists focus on function would be justified after all.

I tend to agree that function is an 'all important notion', as Kroes and Meijers (2006) put it. Nonetheless, I think that the dual nature theorists cannot live up to many of their ambitions if they ignore the points I have been developing. Here are three examples.

5.1. Artefact explanation

One of the ambitions of the dual nature program is to offer artefact explanations. In particular, as Jeroen de Ridder writes:

> Since artefacts are designed, created and used for their ability to exhibit one or a few specific behaviors associated with their function(s), the typical candidate behavior requiring explanation is the behavior that corresponds to the artefact's function. (de Ridder, 2006)

Accordingly, the author discusses the structure of typical mechanistic artefact explanations, examines the role human agency plays in them, relates them to mechanistic explanations more generally, and so forth. This is all interesting indeed.

Unfortunately, the argument in the quote is based on a false premise—as I have been at pains to stress: artefacts are *not* simply designed, created and used for their ability to fulfill a certain function. Hence, it's hard to accept de Ridder's conclusion that artefact explanations are (most saliently) explanations of the kind structure-to-function, or more precisely, mechanism-to-function. If one is interested in an explanation of, say, an artefact's ease of manufacture, the mechanism approach is misplaced; the layered assembly in the A600 scale is a property independent of any mechanism within or of the scale itself. The structure-to-function relation is just one of the many artefactual structure-to-intent relations in need of explanation.

The kinds of considerations I have been discussing are moreover needed to get off the ground a different (and fairly common) type of artefact explanations, namely those accounts that concern the rise and fall of technologies. For instance, why do screws look the way they do? In part, of course, because their particular shape makes them fit for their function; to a large extent, though, their shape is determined by international standards that were drafted out of considerations of compatibility and ease of manufacture.

The standardization process was set off in the early 19 century. Before, screws needed to be handmade, each manufacturer employing his own standards. For the manufacturer this had the advantage of locking in customers, since for repairs and replacements these had to return to *him*. In 1841, however, Joseph Whitworth drafted a standard for screw threads (with a thread angle of 55° and a standard pitch for a given diameter). Soon the standard was adopted by British railway companies, and given the benefits of interchangeability, it became widely accepted throughout Great-Britain. In 1864, then, William Sellers, an American engineer, simplified Withworth's design (with a thread profile of 60° instead of 55° and a flattened tip, instead of a rounded one), which made the screw much easier to manufacture. After some decades of mass production, the Sellers screw was *de facto* the standard screw type in the US. At present, screws predominantly conform to ISO standards, but these are in fact based on Sellers' original specifications (e.g., the 60° thread angle).

Now, to explain the popularity and wide adoption of the Sellers screw (and conversely, the gradual abandonment of the Whitworth screw), talk of functions will not do. The Sellers screw wasn't adopted because it performed its function better than the Whitworth screw, nor because it offered some new functionality. Rather, its popularity was due to its ease of manufacture (allowing mass production, *ergo* its popularity).

As said, for Kroes (2006, p. 137), 'a complete description of a technical artefact involves a description of both functional and structural features'. I believe that the above has proven him wrong.

5.2. Explanations of design

I already expounded the account of design implicit—and explicit, on many a occasion—in the contributions to the special issue (especially Vermaas, 2006; Vermaas & Houkes, 2006; de Ridder, 2006; Kroes, 2006): design is primarily the exercise of determining a physiochemical structure for a prespecified function. In light of my argument, this seems too unconstrained to be an accurate picture of what engineers typically do. It is reasonable to suppose that the function of cars has remained fixed over the years; if so, what on earth have car designers been doing if it's function they are mainly working on?

Here is definition of design, taken from a recent engineering textbook, that is more responsive to my concerns:

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> *Engineering design* is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints. (Dym & Little, 2005)

This conception has three advantages. First, function and form are put on a par, instead of form necessarily following function. Second, Dym and Little do not define the objectives of artifacts in functional terms; they recognize that artifacts may satisfy other human ends. And third, engineers design within a given set of constraints. Again, these need not be functional. In contemporary car design, for instance, a car's function is taken to be fixed, while the engineer's main task is to find reasonable trade-offs between such things as cost, aesthetics, ease of manufacture, environmental soundness, and so forth. Resolving conflicts between these issues is what car designers has kept busy over the last years (decades, century).

Design, thus, might indeed be about determining physiochemical structures. But what these structures are intended to do or intended to be like is more than what's in their functional specification.

5.3. Normativity

The normativity of artefacts, the dual nature theorists argue, derives from their proper function: an artefact's proper function tells what the object *ought* to do. When it doesn't, it is malfunctioning, or more colloquially, it is a bad specimen (Franssen, 2006; Kroes, 2006). And indeed, if one thinks that an artefact's intentional nature is exhausted by considerations of function, there seems no room for normative judgments other than those related to the object's functional performance. But if, as I have argued, the intentional is broader than the functional, the normativity of artefacts will be broader too.

Let me, for purposes of illustration, briefly rehearse Franssen's argument. The author claims that an evaluative judgment like 'this is a good drill' expresses a normative fact: it means the drill functions properly, which gives us a normative reason to use it in case we want something to be drilled. The drill's instrumental goodness, thus, has normative purport in that it induces a pro-attitude toward a certain action (viz. *using* it).

This line of reasoning seems plausible, but can be straightforwardly applied to any of the non-functional intent-related properties I have considered. To a manufacturer, the statement 'this is a good screw' may express the fact that the screw conforms to ISO-standards. The normativity in this case doesn't necessarily derive from a pro-attitude towards usage. The pro-attitude might regard production: given the fact that ISO-screws are easier to manufacture, one has a normative reason to start producing them (rather than sticking to the production of non-ISO screws). Similarly, the statement 'this is a good software package' may express the fact that it is open (or closed) source; the statement 'this is a good engine' that it is clean; the statement 'this is a good product' that it is highly marketable; the statement 'this is a good plug-in' that it is compatible with commonly used plugs; the statement 'this is a good t-shirt' that it is produced under acceptable conditions of labor. And each of these statements may induce pro-attitudes (toward usage, production, buying, selling, maintaining, copying, standard-setting and so on), and hence be said to have normative force.

One may object to my quite liberal attributions of normativity. Am I not extending the boundaries of the normative too much? Perhaps. But two points in reply. First of all, such criticism would just as well apply to Franssen's argument, for I am simply applying his logic to a set of new cases: from good-making properties I derive normative reasons for action. So if one accepts Franssen's claims, it would be natural to accept mine too. Second, I think that norm talk in cases of artefacts is quite common to engineering (one may look for instance at the enormous amount of norms and standards drafted by the ISO), and very useful for that matter: product norms help to protect and guide customers, they help to constrain the design space that engineers need to consider, they can be invoked in case of legal disagreements, and so forth—for a more detailed analysis of this point, I refer the reader to my (Vaesen, 2008).

6. Concluding remarks

To be sure, the dual nature approach offers a great deal for our conceptualization of artefacts. It provides a compelling analytic framework to examine questions of artefact design, ontology, normativity and sociality. And it is certainly true that artefacts, in virtue of their special status in between the physical and mental, raise many pressing questions.

However, the distinction between the physical and the intentional, while correct, is too coarse-grained. In particular, I have argued that much is to be gained from exploring the various subvarieties the intentional harbors, while demonstrating that an artefact's intentional nature cannot be equated with its functional qualities. Human beings intend artefacts to be much more than simple function-bearers, and such intentionality shows in their material basis (the artifacts' physical natures).

I do not claim that the cases I have considered exhaust the intentional nature of artefacts. To give the dual nature thesis something back of its original, orderly appeal, we would need a systematic overview of the non-functional artifactual features that refer to human intent. That, however, is something I defer to another occasion.

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