Reply to Critics

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We are very grateful to our commentators for their critical comments and observations on our research program "The Dual Nature of Technical Artifacts". Philosophy progresses in dialogue. Below we will try to respond to the various criticisms.

Comments on Carl Mitcham's "Do Artifacts have Dual Natures?"

Carl Mitcham argues that our analytic project is part of a larger "trajectory in thought", more specifically phenomenology, which includes Heidegger's analysis of equipment and tools, and Husserl's attempt to return to the things themselves. The historical comparison suggests the need to make conceptual distinctions between different types of artifacts: tools, utilities, structures, machines, appliances, works of art, poems, etc. Is the dual nature the same in each case?

This question asks for more than we aim at in the Dual Nature program. The program mainly focuses on artifacts that are designed by engineers. Our primary aim is to understand the type of artifacts they design and develop, as part of an effort to better understand engineering practice. This is a field often neglected in the philosophy of technology, where the tendency exists to focus on the social, moral or cultural effects of technology in general. Our main notion of artifact is derived from Randall Dipert's (1993, p. 29) analysis, where artifacts form a subclass of the larger class of tools, namely those tools that are intended to be recognized by observers and users as being intentionally made or altered for their specific use. It may turn out to be necessary to distinguish between different types of engineered artifacts within the dual nature program. But poems and works of art do not belong to the artifacts that are studied in our program.

In addition, Mitcham rightly notices in his historical observations that the dual (physical-functional) nature of artifacts reflects in certain ways the old mind-body problem. He suggests that our dual nature approach might be a prolongation of the Cartesian heritage of mind-body dualism, a type of foundationalism that has been subject to numerous critical assaults. Is our account not vulnerable to the same type of criticism?

We believe that there is an important difference between the mind-body problem and our own dual nature problem. The discussions in the philosophy of mind are, among other things, about the ontological reducibility of the

mental to the physical and about the question of whether the mental is in the end superfluous for understanding human behavior. An example is the discussion of mental causation and the possibility of causal overdetermination of human action by mental and physical causes.

The dual nature of artifacts, however, is a different problem. It is not about ultimate reducibility. The problem is rather how to understand artifacts, given that they have two seemingly incompatible conceptualizations: a physical and a functional one. The question of ultimate reducibility can be bracketed here, for even if functional properties may eventually be ontologically reducible to physical properties, there is still a need for an integrated account in the domain of designers, users and engineers. The ultimate ontological answers do not affect here the problem of understanding the dual nature of artifacts in engineering practice. Engineers work with these two conceptualizations when they design and make artifacts and the explanation of the function of an artifact refers both to its physical properties and to the intentionality of its designers and users

Mitcham's second point is conceptual: why technical artifacts, why nature, why dual nature? As to the first question, we would not object to Mitcham's own phrase of "engineered" artifacts, since this is precisely what we intend to focus on. Whether or not our analysis will in the end be relevant for understanding wider classes of artifacts cannot be said beforehand. This needs to be evaluated when the analysis has been carried out. Initially, one would expect that all artifacts that are designed and made for some function could profit from such an analysis. Our use of 'technical' in technical artifact has been primarily aimed at distinguishing the artifacts we would like to focus on from social artifacts, such as laws, parliaments, speech acts (promises, orders), and stock markets. The latter type is constituted to a large extent by human agreement, while their physical realization is often arbitrary and not part of the explanation of what makes the artifact the artifact it is. You can understand much of what money is while ignoring its chemical and physical properties, whereas you cannot understand technical artifacts such as television sets or car engines when you ignore their material properties.

The second question concerns the notion of nature in 'dual nature of technical artifact'. We certainly do not want to add another meaning to the 20 or so senses of the concept of nature that have been distinguished by Lovejoy. What we do intend, however, is to focus on the fundamental character of artifacts, including their ontological characteristics. This shows that we cannot be satisfied with Mitcham's own suggestion of 'character' as an appropriate term for what we mean by 'nature'. Since a character for him is "a second or supplementary nature", this is certainly not what we mean.

The issue is related to Mitcham's final question which goes right into the heart of the dual nature program: why two natures, not three or four? Shouldn't we be careful not to exclude the multitude of characteristics that artifacts exhibit, such as their chemical, biological, dynamical, functional, intentional, or cultural characteristics? The answer to this question is rather straightforward. Given that we are interested in the fundamental properties of artifacts, the great divide here is between intentional properties and non-intentional properties. Intentional properties include the artifact's function, its being a means for an end, its cultural meaning, and its esthetic properties. Non-intentional properties include its physical, chemical and biological properties. These two large classes of properties constitute the dual nature of artifacts. In this respect there are no three or four natures, since these two natures (intentional and non-intentional) cover the properties an artifact may have. Given that these two, very different types of properties play an important role in engineering practice, our challenge is to develop an integrated account of artifacts that incorporate both types. Or, to put it in the language of our research program: to develop a coherent conceptualization of technical (i.e. engineered) artifacts, taking into account their dual nature (fundamental character) as (i) designed and non-intentional physical structures, which realize (ii) intentionality-bearing functions.

Comments on David Baird's "Thing Knowledge – Function and Truth"

Baird's contribution gives rise to a mixed comment. His plea for a materialist epistemology called 'thing knowledge' can be taken as an interesting starting point to fill in a blind spot within traditional epistemology, namely the nature of engineering knowledge. Traditional epistemology has been an epistemology of scientific practice, not an epistemology of engineering practice. But at the same time, his choice for a 'thin' notion of function appears to undermine this claim, because such a notion of function is inadequate to represent the notion of a technical function. At the end of his paper he asks himself: "How thin can we allow our concept of function?" In our opinion his notion is too thin if the aim is to understand the nature of engineering knowledge and the role of the notion of function in engineering practice.

The most striking feature of Baird's materialist epistemology is that it focuses on things and actions instead of thoughts and ideas. Material things 'carry', 'embody' or 'bear' knowledge; in other words, material things play an important 'constitutive' role in knowledge. Within traditional epistemology, with its fixation on justified true belief, this is not the case. Knowledge is primarily associated with our beliefs in claims about the world, and science is

the most systematized enterprise to produce knowledge (it produces statements about the world that are justified on the basis of the available evidence and hopefully true). We agree with Baird that this model of knowledge may be inadequate to understand the role of knowledge in making things and in changing the world. Traditional epistemology may be inadequate to understand more in particular engineering knowledge. In contrast to science, engineering (technology) is not geared to representing the world, but to changing the world and to making technical artifacts. With reference to Searle (1983, p. 7), we may characterize science as having to do with a mind to world direction of fit (the adaptation of beliefs and representations to the world), whereas technology aims at the reverse: a world to mind direction of fit, i.e., the adaptation of the world (physical objects or systems) to our minds.

It seems that traditional epistemology has not taken this basic difference between science and technology seriously; a systematic analysis of engineering knowledge is virtually non-existent (the reason for this may be that often it is tacitly assumed that engineering knowledge is some form of applied scientific knowledge, which leads to the conclusion that the model of knowledge as justified true belief is also applicable to engineering knowledge). We are sympathetic to Baird's approach because it takes the difference between science and engineering seriously; his materialist epistemology is an interesting attempt to develop what could be called an epistemology of engineering.

A closer look at his materialist epistemology, however, raises doubts about whether his approach can do justice to engineering knowledge. According to Baird the notion of function can play the same role in his materialist epistemology as the notion of truth does in traditional epistemology. With regard to scientific knowledge, truth has according to Baird the following features:

(1) Detachment: Scientific knowledge can detach from its context of discovery.
(2) Efficacy: Scientific knowledge can be depended upon to establish appropriate ends.
(3) Longevity: Scientific knowledge can be depended upon into the indefinite future.
(4) Connection: Scientific knowledge establishes a relationship between the world and us.
(5) Objectivity: "The world's voice" has priority in the relationship between the world and us.

Truth is important because in the ideal case it guarantees that scientific knowledge has these properties.

According to Baird, the notion of function can serve, again ideally, the same role in thing knowledge as truth in proposition knowledge. This is obvious for the second feature: if an artifact functions well, i.e., is efficacious, then we can depend upon that artifact to realize certain ends. So, efficacy is no problem. The same is true for detachment: a given artifact may perform its function well independently of its original context of development. Longevity follows because artifacts are expected to fulfill their function for as long as possible although wear and tear prevents them to work forever. Furthermore, functions of artifacts have an objective status: it is not sufficient to wish that a given object should perform a certain function; its function is related to certain objective properties of the artifact. Finally comes connectivity. Just as the truth of a proposition connects our representation of the world with the world itself, so the function of an artifact connects the behavior of an artifact with how we want it to behave. This is for Baird an "obvious and fundamental feature" of functions. It is at the same time a "deeply complex and problematic" feature because it relates function to purpose, to purposeful phenomena, to intentions of designers or users, and to normative issues. This is what Baird calls a 'thick' notion of function.

At this point in his argument, Baird makes in our view a problematic move. He admits that "at some level in some way functions are connected with intentions" but that for his purposes all that he needs is a thin concept of function, that is, a concept of function that is more akin to the notion of mathematical function: "This is how to think about crafted material functions. What we want is a device – an artifact – that reliably associates inputs and outputs, a device that is, in a possible-world-kind-of-way, a set of ordered pairs of inputs and outputs". In this way he hopes to sidestep all issues about intentionality, teleology and normativity associated with the thick notion of material or technical function. A thin notion of function has all the features of detachment, efficacy, longevity, objectivity and connection and that is therefore all Baird claims that he needs.

Is the reliable association of inputs and outputs by a device (artifact) indeed a sufficiently rich notion of (material) function in order to guarantee that the above five features can be fulfilled by this notion of function in a material epistemology? At least two of these features appear to become problematic. First, there is the notion of efficacy. Generally speaking, it does not make any sense to say of a mathematical function or of a set of ordered pairs of inputs and outputs that it is efficacious. Thus, if Baird's notion of function is nothing more than a set of ordered pairs of inputs and outputs, then efficacy

is a problem. Of course, matters become different when we treat the outputs as ends; then the function of a device may be efficacious with regard to the realization of ends (note that the description of the efficacy of scientific knowledge and of functions by Baird explicitly refers to the notions of ends or goals and not to the notion of output!). But in that case, Baird's thin notion of function is in fact a very thick notion because by referring to outputs as ends, purposefulness and intentionality are brought in through the front door.

Also the feature called connection becomes problematic. Baird claims: "Functions connect how an artifact behaves with how we want it to behave." But the description of the function of an artifact in terms of reliable relations between inputs and outputs does not as such tell us anything about how we want the artifact to behave. Any physical system will exhibit a reliable association between inputs and outputs (either on the level of individual inputs and outputs for deterministic systems or on the level of ensembles of inputs and outputs for probabilistic systems) and thus can be ascribed a thin function. But how does that specific function relate to how we want that system to behave. As long as any reliable association between inputs and outputs can pass for a (thin) function of the object, it is not clear how such a thin function can establish a connection between the actual behavior of a system and its intended behavior. The definition of function as a reliable association between inputs and outputs puts no restriction whatsoever on what kind of inputs or outputs are to be considered. There are no relevance criteria and therefore an infinity of functions can be associated with an artifact. Again, the interpretation of outputs as ends does not solve this problem. In the first place, since any kind of output becomes an end, there will never be a discrepancy between the actual behavior of an artifact and its intended behavior (thus, malfunctioning is excluded). And secondly, the same argument as above applies: the interpretation of outputs as ends turns Baird's thin notion of function into a very thick notion of function. In fact, the description of an artifact in terms of Baird's thin notion of function amounts to nothing else than to what is called in the Dual Nature program a structural description of that artifact; it is a mathematical (physical) description of the behavior of that object, but such a description does not say anything about its 'thick' technical function.

To summarize our point: the thin notion of function proposed by Baird cannot do the work it is supposed to do within his materialist epistemology: it fails with regard to efficacy and connection. Because intentionality is in Baird's view such a problematic notion, he is prepared "to trade off the problems of intention for the peculiarity of spider webs and solar system knowledge tokens." In these cases, intentionality appears to be involved at most in a rudimentary way, or to be totally absent and in so far functions are

involved, they might be captured with the notion of the thin, mathematical function. It is highly questionable, however, whether this trade off will allow him to understand technical artifacts as bearers of knowledge. Technical artifacts have functions for which intentionality appears to be essential. In our opinion Baird's material epistemology requires a thick notion of function.

Baird's thing knowledge may turn out to be an interesting suggestion for developing an epistemology of engineering provided he is prepared to accept a thick notion of function; but even then many questions remain. Let us briefly touch on one in particular, namely the question whether knowledge involves belief or representation. There are at least two reasons why in the context of engineering knowledge this idea is problematic. In the first place, know-how is an important element of engineering knowledge. Crafting an artifact involves know how, i.e., practical skills, as Baird's example of the Davenport motor illustrates. These skills have to be learned. But a characteristic feature of know how is that it cannot be learned from textbooks; this kind of knowledge cannot be expressed in sets of statements with regard to which we may form beliefs that these statement are true or false or justified or not. This means that as a form of knowledge know how does not fit into the belief conception of knowledge. But it is highly questionable whether the role of know how in crafting artifacts justifies Baird's proposal to divorce knowledge completely form a knowing subject and to locate it in the crafted artifact itself. In the second place, technological or engineering knowledge often is of a prescriptive nature, in contrast to the descriptive nature of scientific knowledge. It is unclear whether prescriptions involve beliefs or representations. Of course, we may entertain beliefs about a certain prescription, e.g. that it will be efficacious when skillfully performed, or that it is a silly prescription, but that is not to be confused with the idea that the prescription itself is a belief or is of a representational nature. It seems problematic to interpret prescriptive knowledge in a representational way, since the notion of truth does not make sense with regard to prescriptions.

Know how and prescriptive knowledge play an important role in technological knowledge and the above considerations seem to indicate that an epistemology of technology requires a broader approach to knowledge than the traditional belief approach. However, know how and prescriptive knowledge do not seem to require the possibility of thing knowledge since both implicitly or explicitly refer to a knowing subject. In our view, Baird's claim that we will have to allow the radical possibility of crafted artifacts as carriers of knowledge still needs further underpinning; the acceptance of know how as a form of technological knowledge is not sufficient ground to "justify the belief in thing knowledge".

Comments on Daniel Rothbart's "The Dual Nature of Chemical Substances"

Daniel Rothbart has a somewhat different focus in that he is not interested in a philosophy of engineering but a philosophy from engineering, i.e., in a philosophy of science that does justice to the central role of technology in science. Like Baird, he is interested in scientific experiments and the use of instruments. Let us clear one possible misunderstanding right away: we are not claiming that "all material bodies" exhibit a dual nature, but only that artifacts do, more specifically technical artifacts.

According to Rothbart, scientific instruments are based on design-plans. Such plans can be read as epistemic maps guiding our knowledge-seeking practices. They provide experimenters with prescriptions for confronting the world; they guide them in transforming specimens and monitoring the results. These instruments have a dual nature of function and structure. Their function is to provide information about the world by the manipulation and detection of specimens. An absorption spectrometer, for example, bombards a specimen with photons from an artificial source. The transformation of the specimen, then, provides information about the specimen's properties.

Rothbart believes that the structure-function duality represents an important insight in scientific inquiry and experiment. But in his view (and Dewey's) not only do instruments have such a dual nature; chemical compounds have such a duality too during this inquiry. They are "tools used for acquiring knowledge" and they function as "nature's machines" with the capacity to generate movement when sufficiently agitated by instruments. This is an important and challenging claim that provokes discussion.

The first question is to the exact nature of the claim. Should we say that specimens have such a dual nature literally or only metaphorically? Here Rothbart seems ambiguous. On the one hand his formulations suggest a metaphorical reading, when he says that a specimen has function "as if it were a tool used for acquiring knowledge" (our emphasis). On the other hand his idea that the traditional distinction between machines and non-machines is challenged by modern (nano) technology points to a more literal reading. The metaphorical reading does not pose a problem, since it is only an as-if attribution of a function. The literal reading, however, raises questions since it seems to extend the dual nature approach of artifacts to natural compounds and specimens used in experiments.

We can clarify the issue by using Dipert's distinction between instruments, tools and artifacts. An instrument is a natural object used for some purpose, for example a stone used as paperweight. A tool is an object that has one or more of its properties intentionally modified to perform a certain job, for example a tree trunk modified to sit on. Finally, an artifact is a tool that is intended to be recognized as such; it communicates its artifactuality. If we apply this distinction to chemical compounds, the use of a natural compound in an experiment does not give the compound a function yet. It does not seem right to say that it is the function of this natural compound to be used in the experiment; it is only used as such. At most we could say the compound acquires an accidental function in the experiment. This is also evident from the fact that the notion of malfunction does not apply here. If a natural specimen does not work as we expect it to work, it does not malfunction. It simply has properties that did not live up to our expectations in the experiment.

Things are different, however, when compounds are modified or even designed to have certain characteristics which are expected to be useful in scientific inquiry and experimentation. Then they can be said to malfunction, for example when a catalyst (notice the functional description) is not stable enough and disintegrates too quickly. So the question of a dual nature of materials depends on whether they are natural or artificially modified. In case they are artificially modified or designed they are intended to perform in certain ways and may therefore be said to malfunction if they do not do this. So Rothbart's claim seems true when it concerns materials that are artificially modified for the purpose of experimentation. But if this is his claim, it does not conflict at all with our dual nature approach to artifacts. Artificial or artificially modified materials belong to the same class of tools to which our account applies.

Our discussion here is related to the issue of intermediate products (materials, general purpose parts, etc.). What should we say about their functionality? They do not have a specific function yet, but they are to be used in end products to acquire such functionality. Since intermediate products have so many uses, it is difficult to speak of a function they have. A certain plastic with optical properties, for example, may be used in a compact disc to store information, but also in optical cables to convey information or in unbreakable windowpanes. What is exactly its function? The problem we encounter here requires more in depth analysis.

The questions raised by Rothbart make it necessary to explore the boundaries of the notion of technical artifact. When should we say that something is just a natural phenomenon with a structure, or an artifact with a certain function?

Can a specimen or an intermediate product be said to have a function, though it seems to be just a physical or chemical phenomenon characterized by a certain structure? At the other extreme is the question of software. This issue was also brought up at the Dual Nature session at the Aberdeen meeting of the Society for Philosophy and Technology in July 2001. Software does not seem to have a physical structure, thus being the perfect counterexample to our dual nature approach. We believe, however, that software is not a counterexample at all. In so far as software is not just a formal string of symbols, but an algorithm designed to have a certain function in reality, it has to be implemented in a certain hardware environment in order to acquire this function. The combination of software and hardware, then, is the real locus of the functionality, not just the software taken separately. In that respect software is best regarded as an incomplete artifact, in need of hardware to realize its function.

Again, we would like to thank our commentators for their valuable comments on the Dual Nature research program. Once the program is completed we hope to have more 'definite' answers to the many issues that have been raised.

References

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