Gilbert Simondon and the Dual Nature of Technical Artifacts

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1. Philosophical reflection on technical artifacts: why read Simondon?

Philosophical interest in technical artifacts is a fairly recent matter. For a long time, philosophy of technology was more concerned with broad issues such as the influence of technology on society and culture. At such a high level of analysis, the influence of individual artifacts was out of sight, or at best an example for illustration. In the past decade or so, a more analytical approach emerged in the philosophy of technology, accompanied by an 'empirical turn' that stimulated an interest in reflection on more specific and concrete technological developments. In that context the analytical reflection on technical artifacts emerged. Well-known is Randall Diperts' book 'Artifacts, Art Works and Agency' for the way he distinguished natural objects, tools, instruments and artifacts[1]. Other contributions were made by Van Inwagen, Wiggins, and Lynne Rudder Baker[2]. Probably the most extensive effort in this realm was the "Dual Nature of Technical Artifacts" research program that was carried out at the Delft University of Technology in the Netherlands. This program aimed at developing an account for technical artifacts by describing them in two interconnected ways: on the one hand the artifact can be described in terms of its physical properties (its size, shape, weight, color, etc.) and on the other hand it can be described in terms of what it is meant for (its functional properties). The functional properties are relational (intentional) in nature, while the physical are not[3]. Both designers and users reason about artifacts by making connections between these two descriptions. One of the insights that this program produced was that designers not only create a new artifact, but also a use plan for it[4]. Elements of the concept of a use plan were present in earlier literature (such as the idea of a script in artifacts, as developed by Akrich and also Latour), but the use plan in the Dual Nature account is elaborated in terms of action theory. Users may follow the designer's use plan, or come up with their own use plan.

It may seem that the recent interest in analyzing the nature of technical artifacts was not preceded by any earlier efforts, but this is not the case. At least two philosophers can be mentioned as early philosophers of technology who wrote on technical artifacts: Gilbert Simondon (1924-1989) and Hendrik van Riessen (1911-2000)[5]. Simondon was a French philosopher, whose philosophy of technology is sometimes indicated as neo-aristotelian[6]. He studied at the Ecole Normale Supérieur and the Sorbonne University in Paris. As his main publication on technical artifacts, the book *Du Mode d'existence des objets techniques* (from now on to be abbreviated as *Du Mode*[7]) was never translated into English, it remained fairly unknown and is quoted only rarely. If ever it is quoted or discussed it is in the context of Continentally-oriented philosophy of technology. For instance, Andrew Feenberg referred to Simondon's work while discussing possible confusions between what he called primary and secondary instrumentalization[8]. There are a few publications that have Simondon's work as their primary focus. Paul Dumouchel presented a summary of Simondon's main ideas, as explicated in *Du Mode*[9]. Dumouchel, as Feenberg, seems to be more interested in the implication of Simondon's writings for our view on the impact of technology on society and culture than on his ideas about the development of technical artifacts. Simondon's work was also discussed in a paper by Henning Schmidgen[10]. Schmidgen's motive for reading

Simondon was primarily an interest in the history of science and technology more than an analytical-philosophical interest in technical artifacts. Finally I want to mention a paper by Adrian Mackenzie in which he discusses *Du Mode* in the context of a review of the social-constructivist approach to technology[11].

Simondon also features in the survey of important philosophers of technology that was published by the German Verein Deutsche Ingenieure (VDI) in 2000[12]. As could be expected, in French literature he is mentioned more frequently than in English literature, but here, too, there seems to be no publication that discussed his work in the context of a reflection on technical artifacts in the analytical manner, as we find it in the *Dual Nature* program that was mentioned earlier. If at all Simondon as an early philosopher of technology is revived in more recent publications in the philosophy of technology it is always in a Continentally-oriented article on the role of technology in society and culture. That is understandable, because Simondon himself wrote that his main purpose for writing *Du Mode* was to show that there is no conflict between technical artifacts and human culture[13]. Humans and technical artifacts belonged together and, as he phrased it, humans are the conductors in the world-orchestra of technical artifacts[14]. According to him a better understanding of the nature of technical artifacts could prevent people from being torn apart by fear and love for technology. In this respect he disagreed with other voices in that time, such as those of Jacques Ellul, who wrote his *La Technique ou l'enjou du siècle* in 1954, and Martin Heidegger, who published his *Frage nach der Technik* in the same year. Both philosophers emphasized the negative impacts of technology on society and culture, and although Simondon did not mention them, the Introduction of *Du Mode* can be seen as a response to their ideas, and thus it is understandable that we find references to *Du Mode* primarily in Continentally-oriented literature. In a way, the recent efforts to get a better understanding of technical artifacts thereby reflecting on concrete examples of technical artifacts (as promoted in the empirical turn in the philosophy of technology) can be seen as a similar attempt to move away from too general statements about technology that are not tested against real practice, and create a more balanced picture by carefully examining technology 'from inside'[15]. A confrontation of Simondon's ideas with the more recent insights as gained in analytically-oriented philosophical studies on technical artifacts, such as in the *Dual Nature* program, has not been published yet. That is the aim of this article. What I will do here is first present a summary of Simondon's main ideas about the nature of technical artifacts, thereby using the French text of *Du Mode*, and also the publications on Simondon I quoted earlier, but primarily by going back to the text of *Du Mode* itself, and then compare these ideas with the more recent insights as they have been developed in research like the *Dual Nature* program.

2. Concepts in Simondon's philosophy of technical artifacts

In the first place it is important to note that Simondon used the word 'objet' for indicating a process rather than a device or machine. He wrote: "the technical object is not this or that thing, given here and now, but that of which there is a genesis"[16]. So for him, the steam engine as a technical object is not what we usually call a technical artifact but a sequence of engine designs that displays a certain development[17]. Ontologically speaking, for him a technical object is not a material entity, but an event, or rather a sequence of events. At first sight this would mean that we have to be very careful in comparing his ideas with the *Dual Nature* approach, because in that approach the technical artifact is not a process, but a material entity. Simondon did discuss numerous examples of technical artifacts. As long as we are aware of the fact that he sees those artifacts primary as the outcomes of a process we can draw the comparison between his view on these artifacts and the *Dual Nature* view.

In *Du Mode* the term concretization features quite prominently. Here too, we have to be aware of the specific way in which Simondon used the term. Concretization is taking a step from abstract to concrete. That holds both for Simondon's way of using the term and for the common use. In common use this refers to the process of developing an artifact as one that starts with only abstract entities (theoretical concepts, a list of requirements and perhaps sketches) and ends with a concrete object (a prototype or a finished product). But for Simondon abstract and concrete have a different meaning. As his term 'objet' refers to a sequence of artifacts, also his term 'concretization' refers to this sequence, and not to the genesis of one artifact in this sequence, as in common use. He distinguished between craftsmanship (l'artisanat') as a primitive 'abstract' stage, and industry (l'industrie') as a 'concrete' stage[18]. In the stage of craftsmanship technical artifacts are still in an early process of their genesis (that is, earlier in the existence of the technical object-as-process), which can be seen from the fact that there is not yet a convergence or 'condensation'[19] of functions in the parts of the artifact. Each function is realized in a separate part. It is only later in the genesis that parts become multifunctional. Convergence is another important term in *Du Mode* and Simondon wrote that the real challenge in technology is to bring together functions in a structural unit (that is what he called 'convergence') rather than to find a compromise between conflicting requirements[20] We have to note that Simondon used the term 'structural unit' rather than 'part of a device'. This raises the question if his concept of convergence also applied to a bringing together of functions in the whole artifact (as we see it happen frequently today in our alarm clocks that are at the same time radio's; for this there is even a special term: hybrid products). That would explain why it is particularly in industry that we find more concretization, because then less products would be needed for more functions, and thus mass production becomes more worthwhile. In principle it is well possible that Simondon had this in mind, because already in the Introduction of *Du Mode*, he described three levels of entities: elements (parts of artifacts), individuals (artifacts) and ensembles (combinations of artifacts working together)[21]. The examples he used to illustrate the concept of concretization, though, all are at the level of elements (i.e., parts of artifacts).

Simondon's use of the terms 'abstract' and concrete' is by no means obvious and at certain points even clashes with the normal use of terms. Intuitively we would associate the term 'concrete' with the stage of craftsmanship because the use of abstract concepts seems to be more characteristic for the stage of industrialization. Here, again, we have to keep in mind that Simondon's focus is not on the artifact, but on the sequence of artifacts that constitute what he calls an 'objet'. The difference between concrete and abstract does not refer to a concrete artifact versus an abstract concept of the artifact-in-design, but to two stages in the sequence of artifacts. The stage of craftsmanship is a way of developing artifacts that is 'primitive'[22] in that there is a low level of sophistication in the way the functions of the artifact are realized in its parts. In the stage of industry functions are combined in parts in a more sophisticated way, and probably Simondon saw this as a crucial prerequisite for mass production as practiced in the industrial stage. Simondon does not elaborate on this assumption. This makes his terminology confusing, as now we tend to associate 'abstract' and 'concrete' with artifacts and not with the sequence of artifacts. This also obscures the meaning of the terms craftsmanship and industry, because for Simondon they do not sites or phases in the overall history of technology, but to approaches to artifact development. This confusion is enhanced by the fact that Simondon does not explicitly claim that concretization did not take place yet in the historical era of craftsmanship, but only emerged after the Industrial Revolution. Perhaps he would not even want to make that claim, because in principle the approach that he labels as 'industrial' could also have been practiced in the historical period before the Industrial Revolution. This would also explain why he does not need the 'individual' and 'ensemble' levels to illustrate his concept of 'concretization'.

In *Du Mode*, Simondon elaborates in detail a couple of examples in order to illustrate his claim that convergence was the key issue in the genesis of these artifacts. I will describe one of them here: the penthode. This amplifying electronic tube was invented in 1926 by Bernard D.H. Tellegen. Tellegen at that time was a scientist in the Philips Natuurkundig Laboratorium (Philips Physics Laboratory[23]). Simondon described this invention as a step in the genesis of amplifier tubes that started with the triode[24]. In the triode there are still separate parts for different functions: the cathode is for producing electrons, the anode is for capturing them, and there is a grid for regulating the electron flow from cathode to anode. The triode's functioning was hampered by the capacity between anode and grid, which could easily result in an undesired auto-oscillation of the current in the tube. To fix this problem, another grid was added to the design, between anode and grid, and this functioned as an electrostatic insulation. But because of the potential between the anode and this extra grid, and between the extra grid and the original control grid, the extra grid also functioned both as an extra control grid for the anode and as an anode for the original control grid, thus strongly enhancing the amplifying function of the tube (up to 200 times amplification in stead of 30-50 times). So the extra grid functioned both as a solution for the original problem and as an enhancement of the overall function of the tube. This is typical for what Simondon called concretization. This new tube, called the tetrode, had a new problem: now electrons hitting the anode caused secondary emission of new electrons at the anode, which electrons caused other electrons coming from the control grid to be turned back. Tellegen solved this new problem by putting an additional grid between the insulating grid and the anode. By giving it a negative potential (approximately the same as the cathode) the electrons approaching the anode were no longer hampered by secondary emission at the anode. But this additional grid also could be used as an additional control grid. So again functions were combined in an element of the device. By positioning the bars in the additional grid in the electrical 'shadow' of the bars in the original control grid, the secondary emission is reduced (so not only the effect of secondary emission is dealt with, but also the emission itself). Furthermore, the variation in capacity between the cathode and the control grid becomes very small, which suppresses practically every frequency shift when the tube is used in a wave generator circuit. The additional grid is what Simondon called 'over-determined'. Over-determination is the natural effect of concretization. When an element serves more than one function, both functions determine that element. Simondon used the example of the penthode to illustrate how in each step of concretization new conflicts may emerge, but in a next step those will be solved and further convergence of functions in elements will take place. The penthode is a product that was developed in what we normally call an industrial context (the Philips company). The fact that Simondon uses this example to illustrate his concept of concretization clearly indicates that in his terminology the early stage of concretization (craftsmanship) can take place in the context of what in normal use of the term is called 'industry', while in Simondon's use of the term 'industry' it means the later stage of concretization.

In a previous publication, I derived a simple taxonomy of technological knowledge, based on the Dual Nature approach. I distinguished three different types of technological (artifact-related) knowledge, namely knowledge of the physical nature, knowledge of the functional nature, and knowledge of the relationships between the physical and the functional nature[25]. Simondon in *Du Mode* also pays substantial attention to technological knowledge in relationship to technical artifacts. It is the main focus of one of the three parts of this book (Part II on 'Humans and the Technical Object'). In that Part he discusses the genesis of technical artifacts as the object of human knowledge. As for the stages in the genesis of technical artifacts, here too, he differentiates between two types: the knowledge stage of childhood and the stage of adulthood[26]. Knowledge of artifacts in the stage of childhood is intuitive, without an insight into the explanation of the functioning, and focused on working with the artifacts in practice. In the stage of adulthood such knowledge is rational, based on theoretical insight into the functioning of the artifact, and focused on reflections that are more universal than just related to this single artifact. A person with childhood knowledge of artifacts – an artisan – does not really master the artifact but is bound to the rules for usage as learnt in his/her education. A person with adulthood knowledge, though, - an engineer - has freedom to adapt the artifact or its use according to his/her own needs[27]. According to Simondon, there is place for both. The difference between the two types of people has consequences for their education. Childhood knowledge will be transferred in different ways than adulthood knowledge[28].

In the third Part of *Du Mode*, Simondon used the term 'magic' for the phase in which humans only had childhood knowledge of artifacts. In that phase they saw the artifact as a whole and they did not yet differentiate between the purpose of the artifact and the way this purpose is realized in matter. This is what the coming of 'technicity' caused to start. Technicity means that humans realized that there are different ways of reaching purposes through artifacts. From then on reflections on purposes and reflections on the way these can be reached through artifacts also became the domain for different human endeavors. In religion, humans reflect particularly on purposes, while in technology the material realization forms the focus of reflection[29]. Simondon claimed that this also has consequences for the nature of reasoning in religion and in technology. Religious thinking according to him is more deductive. It starts with certain convictions about purposes in life and from those deduces what is needed to realize those. In technology thinking is more inductive, Simondon claimed. It starts with reflecting on concrete artifact and by induction tries to gain more general insights about how purposes can be reached through artifacts[30].

It is interesting to note that Simondon considered natural objects to be the best examples of concretization. According to him the convergence of functions as a fit between physical realization and functional requirements in structural units is optimal in natural objects. Although Simondon nowhere specifies this, we must assume that 'natural object' in his terminology is restricted to those objects in nature to which we apply the concept of 'function'. In the more contemporary debate on the concept of function this happens only in living objects[31]. We speak, for instance, of the 'function' of the heart. Also the implicit evolutionary notion behind Simondon's claim that natural objects are a sort of final outcome of a concretization process suggests that 'natural object' for him means 'biological object', and not minerals or atoms. On the other opposite of the spectrum, where there is not yet any fit between physical aspects and functions in structural units, is the scientific representation of the artifact-in-design[32]. According to Simondon the result of this is that the behavior of natural objects can be predicted more reliably than the behavior of technical objects[33]. The more concretization progresses, the more the technical object becomes like a natural object. To illustrate this Simondon discussed artificially grown plants. Compared to natural plants they have a less effective integration of functions in structures. Artificially cultivated plants have lost the natural ability to survive in cold circumstances (they have become dependant on the greenhouse), and in some cases they have also lost the ability to bear fruit and create a next generation. Concretization would then be the manipulation of such plants in order to make them resemble more and more the natural plant with its abilities to survive and multiply on its own[34]. This is a fairly speculative example, in particular when we realize that nowadays there is much effort to manipulate flowers in such a way that they seem to have an even better integration of functions than natural plants. This is one of the places in *Du Mode* where one gets the impression that Simondon's ideas have been derived from a priori views on reality rather than from reflections on empirical data.

This aspect of context dependence brings us to another concept in Simondon's philosophy of artifacts, namely that of hypertely[35]. In a situation of hypertely the artifact is fully dependant on its environment. It can only function at the interface of two worlds: the world of its own internal (technical) requirements and the external, social (or 'geographic', in Simondon's terms) world in which it is used. To illustrate this, Simondon used the example of the engine in an electric locomotive. On the one hand, it needs to be adapted to the external world in order to obtain its energy, and on the other hand it needs to be adapted to the train that needs its output energy. This is typically the case for what Simondon called 'elements'. These can only function in a larger whole (an artifact, or an 'individual' in Simondon's terminology). This notion strongly reminds of what H.A. Simon wrote in 1969: according to him an artifact functions as a kind of 'interface' between an 'inner' environment, the substance and internal organization of the artifact, and an 'outer' environment, the surrounding in which it operates[36]. The study of this is what Simon calls the 'sciences of the artificial' and here, too, we see an analogy with Simondon's writings, in which we also find the claim that there is such a science[37]. Simondon claims also that in the case of an individual the artifact can function by itself, but there is still a certain dependency from its environment. A windmill is a fully functional device, but it needs the wind to function. The highest degree of context-independence is found in 'ensembles', which are able to create their own necessary circumstances[38]. In any case, the artifact functions on the interface of its internal milieu (with its own conditions) and the external milieu (with its conditions). Simondon uses the term 'evolution' in his discussion of the concept of hypertely. Thereby he does not refer to the Darwinian concept of evolution, but there seem to be implicit references to the Darwinian idea of adaptation to the environment in the way he explains hypertely in technical objects.

Simondon saw a certain pattern in the way elements, individuals and ensembles develop. According to him, first an element develops into an individual and then the individual develops into an ensemble. At a certain moment, in the ensemble a new element may emerge. This element then also can be the beginning of a whole new ensemble. This can be illustrated by the steam engine (the element) that grew out to a steam locomotive and then into a whole transportation system based on steam technology. At a certain moment in this ensemble, the steam engine was first replaced by an electric engine, which became the beginning of a whole new transportation system, based on electric energy. This is what Simondon called the 'saw-tooth' pattern in technological developments.

3. Comparison with the Dual Nature insights

In the first place, it should be remarked that it is too much to call Simondon an analytically-oriented philosopher of technology. There is too much speculation and too little argumentation in his works to justify that. Simondon mostly uses examples to support his claims and there are only few instances where we find solid argumentation to show that the claims have a broader status than just for those examples. Yet, his ideas are sufficiently original to make them worthwhile for further consideration by confronting them with what has been found in the *Dual Nature* approach of technical artifacts. Maybe the Dual Nature findings can be used as the missing argumentative support for Simondon's ideas, or his ideas can lead to an extension of the Dual Nature findings.

In the first place we can note that Simondon already realized that for a full account of technical artifacts it is not enough to discuss either the physical or the functional nature. Simondon phrased this as follows. In the Introduction of *Du Mode*, he criticizes earlier visions on artifacts that regard them either as material constructions ('assemblages de matière') or as filled with intentions ('animés d'intentions') [39]. Simondon claimed that by combining both aspects in one account, a view on technical artifacts results that helps people understand the artifacts around them and accept them as useful parts of their environment. Simondon did not provide any arguments for this, and in that respect the *Dual Nature* program was necessary to come up with such arguments and thus give a more solid foundation to what Simondon brought forward as an intuitive claim. Kroes and Meijers have argued that a description of any artifact is incomplete and ambiguous if it has only one of the two natures[40]. A screwdriver, for instance, can not be adequately described only as 'a device with which one can turn screws', because there are many other devices imaginable to do that, so that someone could develop a wrong image of a screwdriver if that image is based only on the description of the functional nature. The same ambiguity arises when only a physical nature description is provided to define a screwdriver. The same long stick can be used to open a tin can, and therefore a wrong image of the artifact could result from such a limited description. The technical artifact can only be defined unambiguously when both the physical and the functional nature are described. In a good design there is a fit between these two natures. According to Simondon this fit is not optimal, but improves when the process of concretization progresses. He claims that the artifact is always between a natural object (where the fit is optimal) and a scientific representation of the artifact where there is no fit yet. We have already remarked that this claim is a questionable one.

In the second place, Simondon's ontology of artifacts meets the same criteria that have been developed in the Dual Nature program for any ontology of artifacts. Houkes and Meijers have described two main criteria for this: underdetermination (the ontology should accommodate the fact that an artifact can be used for different functions and a function can be realized through different artifacts) and realizability (the ontology should accommodate the fact that a function can be realized through any artifact, and an artifact can not be ascribed any function)[41]. They have shown that some existing ontologies, such as the one developed by Lynne Rudder Baker, do not (yet) meet these criteria. Let us now examine if Simondon's ontology of artifacts passes this test. I would like to propose that this is the case indeed. Simondon has explicitly claimed that each technical artifact is not fully determined. Only natural objects have a perfect fit between parts and functions. Technical artifacts are always somewhere in between a scientific representation in which the link between function and material realization is totally undetermined yet, and a natural object for which the determination is complete. This fits with Houkes' and Meijers' underdetermination criterion. At the same time, Simondon described the process of concretization as one that has a certain necessity, because in the variation of possible next step in the evolution of an object, there are always 'right' and 'wrong' next steps, of which only the right ones will lead to continuation of the development process (just like in biological evolution only the strongest beings will survive, and not just any possible variation). This makes Simondon's ontology fit the realizability constraints criterion.

In the third place, we can observe that both Simondon and the Dual Nature program seek analogies between biology and technology. The way this analogy is analyzed shows an important difference between Simondon's analogy and the one developed in the Dual Nature program. Simondon compares the process of the becoming of an object (object meaning not an individual artifact, but the whole line of development as a sequence of artifacts in which the level of concretization constantly increases) with the evolutionary process through which living creatures have emerged. The analogy led him to his claim that not all variation in an artifact will survive but only the one for which the level of concretization is higher than its predecessor's. In

Simondon's ontology, the object is not an artifact, but an event, or a series of events. His ontology is a dynamic one. In the Dual Nature ontology, it is the duality of natures that defines the being of an artifact. This is a static ontology. Here the analogy with biology is in the concept of functions and the way they are ascribed to physical entities. Vermaas and Houkes have shown that this analogy breaks down in the case of novel artifacts that do not have clear predecessors. In such cases evolutionary (etiological) accounts of artifact functions do not meet reasonable criteria for technical artifact function accounts[42]. The question is, though, if such artifacts exist at all. Simondon's ontology suggests, but without sound argumentation, that this is not the case. There may be elements coming into being in ensembles that form the start of a new development, but even in that case the new element always has some resemblance with the artifact that was used for the same function previously. The diode, for instance, according to Simondon, was a relatively new element because of its asymmetry, and thus the beginning of a new evolutionary line of artifacts, but it can also be seen as a next step in the search for amplifying devices[43]. Neither Simondon nor the Dual Nature program seem to have sound arguments for determining whether or not artifacts necessarily have a predecessor or can be so new that all comparison with previous artifacts does not give any reasonable explanation for its design. A better source of arguments to determine that are such concepts as 'technological trajectories', 'normal technology' and 'revolutionary technology'[44]. These seek to analyze the development artifacts as part of a broader social development. In Simondon's approach and in the Dual Nature approach all arguments for determining whether or not there is a predecessor must be derived from the artifact itself, while in the technological trajectory or normal versus revolutionary approaches such arguments can also be derived from the social context.

The fourth point of comparison I want to discuss is the relation between the physical and the functional nature (in the terminology of the Dual Nature account). The Dual Nature program has shown that both the designer and the user take into account that relation. In that program this has been conceptualized in what is called the use plan. This use plan is an action theoretical account for the way users reason about how to use the artifact, and how the designer, when designing the artifact, puts himself or herself in the role of a prospective user. Here it is the Dual Nature program that is dynamic, whereas Simondon's account is more static. Simondon discussed the relation between physical and functional nature in terms of a fit between a set of functions and a set of parts, whereby the level of sophistication of the artifact (or as Simondon called it, the level of concretization) is defined by the extent to which a minimum of parts can realize all the desired functions. The latter account provides a specific criterion for assessing the quality of the design: the fewer parts needed for all functions, the better. One can pose the question what advantage that gives. But for those who are acquainted with current ideas about quality in design, as elaborated in Total Quality Management tools, there is an immediate resemblance with the desire to reduce the number of parts in a device that forms the basis of several of such tools (for instance, this is clearly the case for Value Analysis and Design for Assembly[45]). Obviously, contemporary design practice seems to justify Simondon's appreciation of a reduction of the number of parts. But the TQM literature seems to fail in producing sound arguments for using part reduction as a general guideline no less than Simondon's book *Du Mode*. Although current practice offers an empirical support for Simondon's claim, giving such an important role to part reduction as the basis for the appreciation of the fit between physical and function al nature remains fairly speculative. The Dual Nature account does not seem to provide such a specific criterion and this is more on the safer side. The disadvantage of that is that the outcomes of such an account may be less inspiring for designers than Simondon's account.

In the fifth place, I want to compare the ways Simondon and the Dual Nature program discuss knowledge. Thereby I will use my own taxonomy of three knowledge types, as derived from the Dual Nature account (knowledge of the physical nature of a technical artifact, knowledge of its functional nature, and knowledge of the relationship between the physical and the functional natures) for comparison with Simondon's taxonomy of two knowledge types (childhood and adulthood knowledge). Simondon's description of childhood knowledge (the knowledge of the artisan) suggests that it mainly contains what I have called knowledge of the functional nature of a technical artifact. Someone having only childhood knowledge knows what an artifact is for, but does not have an understanding of its composition (or broader: its physical nature) neither of why that composition (physical nature) makes it work. Adulthood knowledge (the knowledge of an engineer) then means also having an understanding of the latter two aspects of the artifact. This, however, is too simple to do justice to what Simondon means to say. Simondon would probably not deny that one need not be an engineer to know that a long object can be used to enlarge force (use as a lever). This would be knowledge of the relationship between the physical and the functional nature of that object (which, in my first, naïve analysis would be only in adulthood knowledge and not in the artisan's childhood knowledge). Yet, there one can still differentiate between childhood knowledge and adulthood knowledge here. The adulthood knowledge only recognizes the potential of the long object of serving as a force enhancer, but cannot explain why the object can do that. The engineer, though, with adulthood knowledge can explain that and is even able to calculate how much output force will be generated by a certain input force given the geometry of the situation. The difference between childhood knowledge and adulthood knowledge, therefore, is not the absence of relationship knowledge in the childhood knowledge and its presence in adulthood knowledge, but a difference within that category of knowledge. Apparently there is a childhood version of relationship knowledge and an adulthood version. That obviously raises the question if the other two knowledge types in the taxonomy that was derived from the 'Dual Nature' account also have childhood and adulthood versions. Indeed, it seems possible to make that distinction for the remaining two types, physical nature knowledge and functional nature knowledge. An artisan's knowledge of the physical nature will be limited to the observable and practical aspects of the physical nature, such as size, weight and type of material. The engineer's knowledge will go beyond that and also comprise theoretical aspects of the physical nature, such as the energy band structure in the semi-conducting material. That can make quite a difference. An artisan seeing a transistor for the first time can develop knowledge of certain aspects of its physical nature (it is very tiny and mainly made of silicon), but it will not help the artisan much in using it. The engineer, also seeing it for the first time, will be able to predict that the material in the transistor can be used to amplify an electric current. In a similar way one can distinguish a childhood and an adulthood version of functional nature knowledge. An artisan studying an oscilloscope for the first time could recognize that its steering plates can be used to direct the electron beam to any desired point at the screen, but (s)he will be left wondering what this function might be any good for. The engineer, though, with a deeper understanding of the functioning of horizontal and vertical steering of the beam could predict that the oscilloscope can serve as a means to display an electrical signal. So Simondon's differentiation between childhood and adulthood knowledge can be translated into certain differences within each of the three knowledge types that have been derived from the Dual Nature account of technical artifacts.

Finally, we can observe that the concept of hypertely and the series of element, individual and ensemble is absent in the Dual Nature approach. This approach analyzed artifacts only at the level of individuals, that is, artifacts that can function independently. There is now, however, a new research program that succeeded the Dual Nature program that focuses on sociotechnical systems.

In this program it is exactly those two issues that are dealt with: the fact that artifacts are parts of systems and that these systems operate on the cutting edge of technology and society (the concept of hypertely). It will be interesting to see how this new program will compare with Simondon's approach, once its first results will be published.

4. Conclusions

This article has suggested that it is interesting to go back to earlier philosophers of technology, such as Simondon, who published ideas that were not yet followed up because they were too analytically-oriented to be recognized as interesting in an era in which the overall approach in the philosophy of technology was still Continentally-dominated. Those ideas got lost in the history of philosophy of technology, but now can be re-valued in the context of a more analytically-oriented philosophy of technology. There exists some 'analytic philosophy of technology' avant-la-lettre, be it with a less developed argumentation, but still it is worthwhile to trace it back and see how it might contribute to our current interests.

My analysis shows that as far as analytical rigor is concerned, the Dual Nature account technical artifacts should be preferred over Simondon's more speculative account. Simondon has some very specific claims that in *Du Mode* are supported by various examples, but there are few places only where sound argumentation is presented to elevate the level of generalization. On the other hand, the specificity of Simondon's somewhat more daring claims make it interesting as a source of inspiration, and maybe a more in-depth analysis of Simondon's claims will allow for the development of the argumentation that is missing in *Du Mode*. The fact that Simondon's account does bear resemblance to the Dual Nature account and seems to fulfill the criteria for an ontology of technical artifacts may make that a worthwhile effort.

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Endnotes

1 Dipert 1993

2 References can be found in Houkes and Meijers 2006.

3 Techne 6:2 (Winter 2002) was a special issue dedicated to this program. It was supervised by Peter A. Kroes and Anthonie W.M. Meijers at the Delft University of Technology, the Netherlands. It was carried out by two post doc researchers (Wybo N. Houkes and Pieter E. Vermaas) and two Ph.D. students (Marcel Scheele and Jeroen de Ridder).

4 Kroes and Meijers 2006

5 The latter was a follower of the Dutch philosopher Herman Dooyeweerd, who developed a philosophy that is generally indicated as 'reformational philosophy' because of its religious background. Van Riessen was an electrical engineer by training. In 1949 he received his Ph.D. in a thesis in which he first described the views of various philosophical schools on technology. The second part of his thesis analyses technical artifacts and engineering design in terms of Dooyeweerd's conceptual framework. This framework is based on the notions that reality is complex because it can be described in terms of different aspects (e.g., the physical, the economical, the juridical and the aspect of belief or trust) that can not be reduced to one another, and the regularities or 'laws' that we see in the various aspects. See also de Vries 2005. Van Riessen's work was also discussed extensive by Carl Mitcham in the First Van Riessen Memorial Lecture; see www.aspecten.org/HvRML/LezingHvRML_1.html.

6 For instance, in the Wikipedia encyclopedia on the Internet; see: en.wikipedia.org/wiki/Gilbert_Simondon. Simondon studied at the Ecole Normale Supérieure en Sorbonne from 1944 onward. The reason for this is probably the way Simondon wrote about forms and content. He saw an analogy between humans and artifact in that both are a combination of form (associated by Simondon with such terms as function, thinking, actuality) and content (associated with realization, potentiality, and life). For Simondon this analogy explains why humans are capable of inventing artifacts (*Du Mode*, p. 60). It can be questioned, though, if the fact that Simondon used these terms justifies calling him a neo-aristotelian philosopher, because this use of the terms 'form' and 'content' is different from Aristotle's.

[7] In this article I will quote from the 1989 edition: Gilbert Simondon, *Du Mode d'existence des objets techniques*. Paris: Aubier. The original edition was published in 1958. *Du Mode* was originally the 'thèse complémentaire' for his doctoral thesis titled *L'individu à la lumière des notions de forme et d'information*, of which the first volume came out in 1964 and the second in 1989.

[8] Feenberg 2000

[9] Paul Dumouchel 1995

[10] Henning Schmidgen 2004

[11] Mackenzie 2005; There is also a dissertation on Simondon by Vincent Bontems, published in 2004, but it remained unpublished; I was not able to consult it for this publication.

[12] Hubig, Huning and Ropohl 2000

[13] *Du Mode*, p. 10.

[14] *Du Mode*, p. 11.

[15] Kroes and Meijers 2000

[16] *Du Mode*, p. 20 (my translation).

[17] In this article I will use the term 'technical object' to indicate Simondon's 'objet techniques' and the term 'technical artifact' for the material entity, in the same way the *Dual Nature* program uses that term.

[18] *Du Mode*, p. 24. It is interesting to note that the difference between craftsmanship and industry also plays an important role in the writings of the other early analytical philosopher of technology I mentioned, namely Hendrik van Riessen. For Van Riessen, though, the difference lies primarily in the fact that the influence of science on technology transferred the characteristic of universality to technology, which resulted in uniformity of products in the industrial approach rather than unique products in the craftsmanship approach. This is clearly different from the way Simondon differentiates between the two approaches or stages. Van Riessen explains the difference from the perspective of production and quantity, while Simondon uses the perspective of design and quality.

[19] The latter term is used on p. 34 in *Du Mode*.

[20] *Du Mode*, p. 22. This is an interesting view, because in most literature reconciling conflicting demands is seen as the core of design problem. Apparently, for Simondon there is a more important challenge.

[21] *Du Mode*, p. 15. Probably the term 'ensemble' can be seen as an equivalent of the term 'system'.

[22] *Du Mode*, p. 24.

[23] A full history of this industrial laboratory, including more details about Tellegen and his penthode, can be found in Vries 2005. See p. 39 and 40 for the penthode, which in the pre-WWII period was one of the most important patents for the Philips company as this device became a standard for amplification of signals for communication worldwide. Tellegen and his penthode are also described in Blanken 2003. Blanken is the director of the Philips Company Archives.

[24] His account can be found in *Du Mode*, pp 27-34.

[25] Vries 2003

[26] Simondon uses the terms 'minorité' and 'majorité' in French for this (*Du Mode*, p. 85). These are not to be confused with 'minority' and 'majority' in English.

[27] Later in *Du Mode*, on p. 251, Simondon admits that users, too, can have such knowledge, which enables them to use the artifact in ways that differ from what the designer had in mind.

[28] Although Simondon did not use these terms, probably what he refers to is the difference between vocational and general education. Still today the difference between the two is the content of much debate.

[29] *Du Mode*, p. 157.

[30] *Du Mode*, p. 233/4.

[31] See, for instance, the collection of essays in Ariew, Commins, and Perlman (eds.) 2002.

[32] In Simondon's terminology, this representation is abstract in a double sense: it is not yet materialized, but also is does not show the convergence of functions that defines concreteness in Simondon's use of that term.

[33] *Du Mode*, p. 35.

[34] *Du Mode*, p. 47.

[35] *Du Mode*, p. 56.

[36] Simon 1969

[37] Simondon uses the name 'mécanologie' for that science.

[38] This distinction strongly reminds of one made by Simondon's contemporary philosopher of technology, Van Riessen. He defined two situations: one in which the device loses its meaning outside the environment in which it normally functions (e.g., the sledge of a lathe, which can only be used in such a lathe) , and one in which the device can be taken out of that environment and be put in a different environment where it can also function, though

maybe in a slightly different way (e.g. a gear which can be used in a clock but also in other devices). The first situation is called a 'part-whole relationship', and the second situation is called an 'enkapsis'. Van Riessen took both terms from Dooyeweerd and applied them to technical artifacts.

[39] *Du Monde*, p. 10 and 11.

[40] Kroes and Meijers 2006

[41] Houkes and Meijers 2006

[42] Vermaas and Houkes 2003

[43] *Du Mode*, p. 40.

[44] Constant 1980

[45] See, for instance, Fox 1993 and Boothroyd, Dewhurst and Knight 1994.