From Naturefacts to Artifacts

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Abstract

This paper discusses the nature and production of artifacts and the distinction between artifacts and unmodified natural objects used for some purpose, called by Wendell H. Oswalt "naturefacts". Artifacts are defined in terms of productive actions, that is, the procedures for making them. Following the taxonomies developed by Oswalt and Benjamin Beck, productive actions are divided into four basic action types: separation, reshaping, conjunction, and replication. The sortal descriptions (type-descriptions) of the resulting artifacts can be either count nouns or mass terms, and the artifacts can be either independent objects or dependent parts of some parent object, the substrate of the artifact.

Keywords: Artifact, Dependent object, Intention, Productive action, Residue, Stone tool.

I

Aristotle divided existing things into "those that exist by nature" and those existing "from other causes". The former include "the animals and their parts…, and the plants and the simple bodies (earth, fire, air, water)"; whereas the things existing "from other causes" include "a bed and a coat and anything else of that sort, *qua* receiving these designations – i.e., in so far as they are products or art" (*Physics*, Book II, 192 b 8-18). Aristotle makes here a distinction between natural objects and artifacts ("artificial products", *ibid*., 192 b 28), and describes the latter as products of art, the art of making things. He distinguishes making (production, *poiesis*) from acting (doing, *praxis*); making aims at an end other than itself, the intended product, whereas "good action itself is its end" (*The Nicomachean Ethics*, 1140 b 5-7).

The art of making something requires intentional agency. Following Aristotle's characterization, an artifact may be defined as an object that has been intentionally made for some purpose. The sense of the word is shown by the expression itself. It is derived from the Latin words 'arte', ablative of 'ars', art, and 'factum', the past participle of the verb 'facere', to make. The *Oxford English Dictionary* defines an artifact (artefact) as "anything made by human art and workmanship; an artificial product." According to *Webster's New Collegiate Dictionary* (1975), an artifact is "a usually simple object (as a tool or ornament) showing human workmanship or modification", or in a wider sense, as "a product of civilization."

Making something requires a maker or an author; thus the concepts *author* and *artifact* are correlative concepts. The concept of authorship is understood here as involving the same kind of intentionality as the concept of artifact. Complex artifacts are often made by several authors with joint or interdependent productive intentions. In such cases the expression 'the author' can be taken to refer to a collective of individual authors.

The scope of intentional productive agency is not limited to human beings. Many animals not only use tools for different purposes, mainly for obtaining food, but also manufacture simple tools (Beck 1980, 105-115; Shumaker et al. 2011). In a recent experiment, a New Caledonian crow called Betty faced the task of retrieving food from a small bucket placed in a vertical tube. Betty picked up a straight metal wire provided by the experimenters, bent it into a hook, and then used the hook to retrieve to bucket and the food. (Weir, Chappell, and Kacelnik 2002.) The action required for the solution of Betty's problem, bending a wire into a hook, was "unnatural" in the sense that in their natural environment, New Caledonian crows do not normally find metal wires and transform them into tools. What Betty did was apparently an instance of intelligent, goal-directed action; thus the hook made by Betty counts as an artifact. In Wolfgang Köhler's famous experiments, chimpanzees were observed to join sticks to make reaching tools in order to obtain otherwise inaccessible food (Köhler 1927, 99-172; Beck 1980, 114). Tool manufacture is not limited to animals living in captivity as subjects of experimentation, but has also been observed in the wild, for example, chimpanzees and some birds have been observed to detach twigs from branches of trees and strip leaves from them in order to make them suitable for reaching termites or ants (Beck 1980, 106-107, 114), and chimpanzees crush leaves together to make a sponge to wipe clean the

inside of a hard-shelled fruit or to gather up ants (McGrew 1992, 139-144). Wild New Caledonian crows have been observed to make hook tools by detaching a forked twig from a *Cunonia vieillardii* plant and by trimming the detached twig into the form of a hook which can be used for obtaining food. Hunt and Gray (2004, S89) note that "New Caledonian crows appear to have a rudimentary technology analogous to that of the early humans. This rudimentary technology includes the cognitively demanding task of crafting tools."

The oldest known human (hominid) artifacts can be traced back to the Early Stone Age of Africa, some 2.5 – 2 million years ago. They are flaked stone tools found in the vicinity of the Olduvai Gorge in Tanzania, in Koobi Fora, Kenya, and in other sites in East and South Africa, made by *Homo habilis* and other ancestors of contemporary humans. (Isaac 1986/1989, 357-368; Schick and Toth 1993, 78-92, 102-105; Toth and Schick 2000, 668-670; Schick and Toth 2006, 10-16, Balme 2008, 510-511.) They were usually made by striking off flakes from a suitable piece of rock (for example, basalt, quartz, or quartzite) with a hammerstone in such a way that the resulting sharp edges of the rock made it a practical chopping or cutting tool. The sharp edges of the detached flakes could be trimmed and "retouched" further so that they could be used as light-duty tools. (Oakley 1964, 38-39; Schick and Toth 1993, 94-100; 2006, 4-9.) The early hominids probably also used tools made of wood and bone, but such materials are unlikely to survive over long periods of time. Stone tools, being relatively indestructible, provide the best record of early hominid technology. The earliest discovered instances of wood artifacts are about 400,000 years old, wooden spears and spear tips found in Clacton, England, and Schöningen, Germany. (Kouwenhoven 1997, Oswalt 1976, 206, Balme 2008, 511.)

II

According to Robert C. Dunnell (1977, 117), an artifact is "anything which exhibits any physical attributes that can be assumed to be the results of human action." Like the dictionary definition quoted above, this definition covers only human artifacts. Kathy Schick and Nicholas Toth have proposed an essentially similar definition, and characterized (human) artifacts as "objects that have been modified by humans, either intentionally or unintentionally." Thus they take the modification of an object as sufficient for artifactuality, regardless of whether the object has been used for any purpose: "For instance, when humans make a spear out of a wooden branch, a lot of wooden shavings are incidentally created as a by-product. But both the spear and the debris generated in making it are artifactual: they have been modified by humans" (1993, 49). Schick and Toth call both intended and unintended products of manufacturing activity "artifacts". In the same way, William Andrefsky Jr. (2001, 2) has observed that the debris (*debitage*) found in archaeological sites has "gained importance as an artifact that can help interpret aspects of prehistoric human technology." James L. Gould (2007, 49) defines an animal artifact as "any creation on the part of an animal, using and/or modifying available materials, which is useful to it or its offspring." According to these definitions, artifacts need not be intentionally produced objects. Many of the "animal artifacts" described by Gould, for example, the nests of wasps and spiders' webs (2007, 256-257), are made by animals to which we are not inclined to ascribe intentionality. A spider's web may be called as a hunting tool; it is made by a spider and is useful for the spider and its offspring.

Dunnell observes that the concept of artifact has been defined differently in different research contexts. His relatively wide definition reflects the use of 'artifact' as a general term for all objects that students of prehistory may wish to investigate and explain in their research. but he notes that the use the term is often restricted to "intentionally manufactured items" (1977, 120-121). The concept of artifact is understood in this way by Wendell H. Oswalt, who distinguishes artifacts (in the proper or strict sense) from the by-products or residue of productive activities, and defines an artifact as "the end product resulting from the modification of physical mass in order to fulfill a useful purpose" (1976, 24). According to Oswalt's characterization, the intentionality of production is an essential feature of artifacts. He avoids using the qualification 'human' to acknowledge that other species also make things or various purposes. Both artifacts in Oswalt's sense and various by-products of manufacturing activities are of interest to anthropologists as sources of information about past cultures. The intended products, the objects made in order to be used for the maker's purposes, may be called artifacts in the strict or proper sense, and distinguished from the residue of productive activities. Below I shall use the word 'artifact' usually in this sense, and use the term 'animal artifact' for artifacts in Gould's sense, not necessarily involving intentionality. Thus ants' nests are animal artifacts, but not proper artifacts, whereas Betty's hook and the tools made by chimpanzees and human beings are proper artifacts. Animals can be regarded as artifact makers or "authors" in the proper sense only to the extent we are willing to ascribe intentionality to them.

In the case of animal artifacts, it is also possible make a distinction between the artifact and the residue. Artifacts are the objects which are "useful to [the animal] or its offspring" (Gould 2007,

249). Making such objects may also produce residual objects which are not useful to the animal. Moreover, we can distinguish here between different degrees of artifactuality on the basis of the materials used. In some cases the material of the artifact consists of secretions of the animal's body, as in the case of the cocoons made from the silk produced by insect larvae or the spiders' webs made from the silk spun by spiders by means of their spinneret glands. On the other hand, many animal artifacts are made at least partly from materials external to the animal. An anthill made pine needles, earth, and sand is an example of this type of animal artifact. One of Gould's examples is the desert spider's use of flat stones to surround their burrow entrance (2007, 251). The use of external material is essential for making proper artifacts, and artifacts made from materials external to the animal may be regarded as representing a higher degree of artifactuality than those made exclusively of secretions from the animal's body.

III

Objects found in nature, possibly carried to a new location, and used as tools, form an intermediate stage between natural objects and genuine or full-fledged artifacts, viz. object modified in order to make them more suitable for the agent's purposes. Wendell Oswalt (1973, 14-17; 1976, 18-23) has coined for such objects the term *naturefact* ("made by nature"): "Naturefacts are natural forms, used in place or withdrawn from habitat, that are used without prior modification by creatures" (Oswalt 1976, 18; see also Schnurrenberger and Bryan 1985, 133-134; McGrew 1992, 131-132; 2004, 104; Schick and Toth 1993, 92; Baber 2003, 40; Basalla 1988, 50, 55.). A stone picked up from the

ground and used as a hammer, for example, a hammerstone used for making flaked stone tools, is an example of a naturefact. Naturefacts have also been called "pseudo-artifacts" (Schnurrenberger and Bryan 1985, 134). The concept of naturefact is closely related to that of a *manuport* (from the Latin words 'manus', hand, and 'portare', to carry). defined as a natural object that has been carried and deposited somewhere without additional modification. In archaeological research the expression is often used to refer to pieces of stone which are assumed to have been carried around in order to be used as tools or as raw material for tools or for some other purpose. (See de la Torre and Mora 2004, 273-274; Bednarik 2002; 2003, 412; Schick and Toth 1993, 145-146.) Manuports are essentially portable objects; thus they can be regarded as a subclass of naturefacts. Naturefacts (in the sense defined by Oswalt) are a subclass of *ecofacts*, that is, non-artifactual objects and materials that have not been modified by human beings but are relevant to the interpretation of an archaeological site. (Dickson 1996, 75; Ewen 2003, 6; see also Renfrew and Bahn 2008, 51-52, 580.)

The distinction between naturefacts and artifacts depends on what is regarded as the intentional modification of an object. In the field of art, the so called "found objects" (found art) are analogous to naturefacts. An object found in nature (for example, a rock or a skeleton) and presented in an art gallery without further modification is an artistic (or aesthetic) naturefact. Often the so-called found objects are not natural objects, but objects originally made for non-asthetic purposes (such as a bicycle or a washbasin), and subsequently adopted as objects of aesthetic contemplation. This way of creating art is analogous to the adoption of an artifact for a new use, and to the adoption of a natural object as a tool. In most cases, however, the works of found art are

assemblages of natural objects or artifacts collected together by an artist. Such works are genuine artifacts; they are intentionally made for aesthetic purposes by using naturefacts and or other artifacts as parts.

Artifacts cannot always be distinguished from natural objects or from the residue of productive activities on the basis of any physical, structural properties. For example, wood-shavings may be by-products of a carpenter's work on a piece of furniture, but similar wood-shavings may also be intentionally produced in order to be used for ornamental purposes. In the former case the shavings are residue, in the latter they should be regarded as artifacts. Here the distinction between the artifact and the residue is determined by the maker's intentions and the way the objects are produced. During the production process the maker's interest and attention are directed mainly at the object or objects he intends to turn into an artifact, especially at their "good-making properties", that is, the properties which would make the artifact good for its intended purpose (cf. von Wright 1963, 26-32). In the case of stone stools, the identification of the earliest artifacts is difficult, because the products of the first attempts at tool-making may have been indistinguishable from naturefacts usable as tools. Naturefacts which had been found useful for some purpose, for example, sharp-edged pieces of stone, have probably served as models for the early artifacts. (Basalla 1988, 50; Petroski 1992a, 3-4.) Certain observable features of a piece of stone, especially what geologists call *conchoidal fracture*, which means that the fractured surface of the rock has smooth undulations resembling the surface of a shell, serve as evidence for intentional production, namely flaking, but it is not sufficient or infallible evidence, because similar fractures can also be

produced by natural geological forces. (Schick and Toth 1993, 94-96; Oakley 1964, 9-14; Schnurrenberger and Bryan 1985, 133-139)

IV

Artifacts can be classified in different ways: on the basis of their intended use, method of manufacture, technological complexity, form, material properties, style, or on other grounds. The simplest artifacts, made by minimal alteration of natural objects or other locally available materials, are called in the archaeological literature *expedient* or *improvised* artifacts. (Cf. Tomka 1993, 15; Jones, Beck, and Grayson 1989, 6.) Betty's hook and other artifacts made by animals tend to belong to this category. I have found that a straightened small paper clip can be used as a toothpick if proper toothpicks are not available, thus it can be regarded as an expedient or improvised artifact. Prototypical human artifacts are usually more complex and their production depends on advance planning and design as well as the use other artifacts as production tools. Even a relatively simple artifact type, such as the present-day Gem paper clip, is often the result of a long design and manufacturing history. (See Petroski 1996, 8-42.)

In philosophical discussions on the nature of artifacts they are often described as having "intended proper functions" (Rudder Baker 2008, 3; see also Simon 1996, 3), and identified by their intended use. Hilary Kornblith (1980, 112) observes: "At least for the most part, it seems that what makes two artifacts members of the same kind is that they perform the same function."

For example, Wendell Oswalt has divided the artifacts of food-getting technology on the basis of their use into implements and facilities, and distinguished between two kinds of implements, instruments and weapons, and two kinds of facilities, tended facilities, requiring the physical presence of a person, for example, a drag net, or a lure used in fishing, and untended facilities, functioning in the absence of persons, such as a fence around a field. (Oswalt 1976, 107; 1973, 25-27; McGrew 2004, 104-105; 1992. 131-133.) This is the way an artifact is presumably regarded by its user, but it is not the only basis of artifact classification. For example, the artifacts of visual arts are divided on the basis of their production method into drawings, paintings, prints, and photographs, and prints are divided into etchings, engravings, woodcuts, lithographs, and other kinds. A drawing or a photograph can serve many different purposes; it may be an object of aesthetic contemplation, or it may be used to help to identify some person or object. In archaeological research artifacts are usually classified on morphological or stylistic grounds or on the basis of other observable features which serve as evidence for hypotheses about their intended function. (Adams and Adams 1991, 217-225; Read 2007.)

As regards the production methods, Oswalt has distinguished four basic modes of artifact production or "production principles", *reduction*, *conjunction*, *replication* (*multiplication*), and *linkage*. (Oswalt 1973, 30-34, 169-172; 1976, 203-205.) According to Oswalt (1973, 170; 1976, 203), "the most basic principle of artifact production" is reduction, "an act of withdrawal or physical separation from a greater mass," that is, the reduction of a mass, "natural or man-made, to produce a functioning form. A one-part artifact is made by taking material away from a larger mass,

to produce a functioning form. The physical operation is that of subtraction, withdrawing from, or diminishing in size." (1976, 203.)

Oswalt gives three kinds of examples of the application of what he calls the reduction principle (the method of reduction). (1) Breaking a limb from a tree to serve as a club, and pulling a quill out of a porcupine skin to use as an awl. (2) Making a flint scraper by removing flakes from a piece of rock by means of a hammerstone. (3) According to Oswalt, reduction also occurs "when grass is detached from a clump, wadded up, and used as a sponge," or when a leaf is removed from a tree and then rolled into the shape of a cone so that it can be used for carrying water. Oswalt notes that examples of the third kind "illustrate the possibility of reduction without the taking away of any part or piece of the material used." (1976, 203.)

I prefer to use the word 'separation' (instead of Oswalt's 'reduction') as a common term for the procedures used in examples of the first and the second kind. They involve the separation of an object (a part or piece) from another object or a division of an object into two. Benjamin Beck (1980, 105; see also Shumaker et al. 2011, 10-11, 216) has distinguished between two forms of separation which he calls *detachment* and *subtraction*. According to Beck, "the simplest and most common [mode of tool manufacture] is severing the fixed attachment between one environmental object and another so that the first object can be used as a tool"; Beck calls this detachment. Subtraction consists in "removing an object or objects from another unattached object so that the latter can serve more usefully as a tool." According to Beck, removing a branch from a tree so that the branch can be used as a club exemplifies the first mode, whereas removing leaves from a twig

so that the twig is can be used for termite fishing is an example of subtraction in Beck's sense. Oswalt's first example is an instance of detachment, the second example is an instance of subtraction. This distinction presupposes an asymmetry between the objects resulting from the separation, namely, the distinction between the subtracted object or objects, the *subtract* or subtracts, and the *remainder* of the *source* or *parent* object. The parent object is also called the *substrate*. Beck's definitions fail to create this asymmetry. If the intended target object, for example, the object to be used as a tool, is the subtract, the action is an instance of detachment, but if the target is the remainder, Beck calls the action subtraction. Since the physical operation can be described as subtraction in both cases, I prefer to use the word 'reduction' for what Beck calls subtraction, and the word 'separation' as a common term for detachment and reduction (i.e., for Oswalt's "reduction").

In separation, the parent object is reduced by detaching a part or parts from it; thus the same individual action may be regarded as reduction or detachment, depending on the agent's intention. If a chimpanzee removes leaves from a twig in order to use the twig for termite fishing, the resulting artifact is made by reduction, but if the leaves are removed for the purpose of using them for wiping, the action is an instance of detachment. (Beck 1980, 105). If the chimpanzee intended to use both the twig and the leaves, the action would count both as a reduction and as a detachment. If the remainder is not the intended artifact, it usually retains the sortal identity of the parent object without acquiring a new sortal identity. When a branch is removed from a tree, the remainder of the tree is a tree, and the same tree as the parent tree. A tree does not lose its identity when a branch is removed from it. Often the distinction between detachment and reduction depends simply on the

relative sizes of the separated objects; the smaller object is tends to be regarded as the subtract. An artifact made by detachment is originally a part of the parent object, and when it is intentionally separated from the parent, it can usually be individuated by new sortal description which was included in the maker's productive intention.

The difference between two kinds of stone tools made by flaking, *core tools* and *flake tools*, illustrates the distinction between reduction and detachment. The source object of a stone tool is called a *core*. A core tool is obtained by *core reduction*, that is, by removing flakes from the core to give it sharp edges which make it suitable for cutting or chopping. The flakes are made by detaching them from the core, and from the standpoint of making a core tool (core reduction), they are residue, also called *debitage*. (Andrefsky 2001, 2; Isaac 1986/1989, 356.) If the flakes are then trimmed and "retouched" in order to improve them as (say) light-duty scraping tools, they are called flake tools. (Oakley 1964, 38-39.) Flake tools are obtained from the core by detachment and subsequent reduction. Thus the same kind of action of separation counts as reduction or as detachment, depending on one's point of view: reduction and detachment are correlative concepts. (See Kooyman 2000, 9-19.)

If the distinction between the subtract and the remainder cannot be made in a nonarbitrary way, there is no conceptual difference between detachment and reduction. For example, if a long stick is broken into two in such a way that one (or both) of the resulting sticks can be used as a hiking-pole, the action is obviously an instance of separation or reduction (in Oswalt's sense), but it cannot be described as detachment or as subtraction (in Beck's sense), especially if the two

resulting sticks are of approximately equal length. It is important to note here that the subtract-remainder distinction is independent of the artifact-residue distinction.

There is only a marginal difference between an artifact produced by a single act detachment and a naturefact. In the case of detachment, the intended target object is originally a part of the source object and it is modified only by detaching it from the source. A naturefact may also be said to be "modified" in the sense that by picking it up and carrying it to another location the agent changes its relation to its environment. Both action types involve a deliberate selection of a suitable object from the agent's environment. The naturefact can be said to undergo what Peter Geach (1969, 71-72) has called a "Cambridge change", and the action might be called "Cambridge modification". The expression 'Cambridge change' refers to all changes involving an object, including changes in its relations to other objects, as opposed to changes in its "real", internal properties, signified by monadic predicates. (See Cleland 1990, 257; Mortensen 2008.)

It may be argued that a single act of detachment is not enough to produce a genuine artifact, especially if the detached object is not regarded as an instance a new object type identified by a new sortal description. According to the US Supreme Court's unanimous ruling in June 2013, the isolated human genes called BRCA1 and BRCA2 are not patentable, because "separating a gene from its surrounding genetic material is not an act of invention," as Thomas wrote in the opinion of the court (Bravin and Kendall 2013). Isolating a gene from its surrounding material is an act of detachment, but this action did not make the company that isolated the gene its author (maker). The Supreme Court in effect decided that natural DNA, even

when isolated, is not a new artifact type; in this respect it differs from cDNA (Complementary DNA), which is synthesized from mRNA (Messenger RNA; for a description if this process, see Primrose and Twyman 2009, 102-103). Complementary DNA can be regarded as a genuine artifact type. When an artifact is made by separation, its production usually requires several acts of separation as well as other productive action types.

Another mode of artifact production is *reshaping* or *restructuring* (Beck 1980, 105). This is an action of changing the form or structure of the source object in such a way that it can be used for some purpose without subtracting any part from it or adding anything to it. Betty's hook is an example of an artifact made by reshaping. By changing the shape of a wire Betty made a new (kind of) object, a hook. A familiar example of a simple artifact made by reshaping a piece of metal wire is a paper-clip; in this case the reshaping is done by a machine. Subtracting a part or parts from a source object obviously changes its shape, but reshaping does not necessarily involve any act of separation, as the example about Betty's hook shows. Oswalt's example of crumpling grass in such a way that it can be used as a sponge is an instance of reshaping, but detaching the grass from a clump is of course a case of detachment. Artifacts are usually produced by a sequence of different action types, detachment, reshaping, and reduction.

Separation and reshaping produce simple artifacts. More complex objects, composite artifacts, can be produced by joining objects together. Oswalt (1976, 203) calls this production method *conjunction*, and the objects joined together (the "conjuncts") *technounits* of the artifact. (This (physical) operation of conjunction must of course be distinguished from the operation of

conjunction in logic.) Oswalt defines a technounit as "an integrated, physically distinct, and unique structural configuration that contributes to the form of a finished artifact" (1976, 38; see also Oswalt 1987, 82, 93). More simply expressed, technounits are the different kinds of parts put together during the construction of an artifact. The conjunctive elements perform different functions in a completed artifact, For example, a knife which consists of a blade and a handle attached together is a conjunctive artifact, and these parts have different functions in the artifact. The use of a plummet (plumb-line) involves three technounits, the plumb-line itself, the weight at the end of the line, and a nail for attaching the line to an object. Water mixed with shredded leaves and used as a medicine is also a conjunctive artifact, with water and leaves as technounits (Oswalt 1976, 204). This example shows that the sortal nouns (sortal descriptions) for artifacts can be either mass terms (for example, tea or coffee) or count nouns (e.g., a knife). A sortal description determines the identity of an object or substance and the criteria by which it can be distinguished from other objects. Manufacturing artifacts identified by mass terms often requires reshaping, for example, heating water in the case of tea, and fermentation for wine.

The technounits of a conjunctive artifact may be detachable pieces, or they may be fused together. In the latter case the artifact may be said to have been made by fusion. This can be regarded as a special case of conjunction.

Separation, reshaping, and conjunction are the most basic artifact production methods. Peter Simons and Charles Dement (1996, 264) have used the terms 'removal', 'forming', and 'assembly'

for these basic action types. More complex procedures usually consist of sequences of these action types.

Oswalt distinguishes conjunction from what he calls *replication*, which means crafting two or more similar structural elements to function together as a part of artifact (1976, 204). The replicated elements function together as a single technounit. The four tines of a fork and the pistons and cylinders of a four cylinder internal combustion engine are examples of the application of the replication principle. The distinction between conjunction and replication depends on the individuation of the technounits comprising the artifact. The conjunctive parts of an artifact are distinct technounits; thus the operation of conjunction increases the complexity of the artifact, measured by the number of its technounits, but replication does not, because the replicated parts of an artifact count as a single technounit. The distinction between replication and conjunction depends partly on functional criteria, the functions of the parts joined together. If artifacts are classified solely on the basis of the physical operations by means of which they are produced, replication may be a form of conjunction or reshaping, depending on how the replication is achieved. However, any action has an internal, mental side, a productive intention, and conjunction and replication differ in this respect; they are governed by different intentions, and may be regarded as different production principles.

Oswalt also characterizes artifact production by means of a fifth "production principle" called *linkage*, which means the production of separate artifacts which are intended to be used together, and "joined in a technical manner in their primary usage." (Oswalt 1976, 204.) Examples

of artifacts produced in this way include a mortar and a pestle, a bow and a violin, and the locomotives, railroad cars, railway tracks, and the signaling and communication system of a railway network. The entire rail transport system of Finland is can be regarded as a complex linked artifact created for the purpose of transporting of passengers and cargo. Linkage is a design principle rather than a production principle, based on the intended primary functions of the linked artifacts. The linked artifacts are designed to be used together or one of the linked artifacts is made to facilitate the use of another artifact. Linkage does not describe an action type required for the production of an artifact; the production method used in making linked artifacts may be separation, conjunction, reshaping, or replication, or any combination of these.

The classification given above is based on very general descriptions of productive actions. There are different ways of performing these actions, that is, different techniques or *routines* for performing them. Any description of an object, event, or a state of affairs can be transformed into an action description by means of the verbs ‘to make’, ‘to build’, ‘to bring it about that’, or some other expression signifying agent causation. For example, ‘to build a perpetual motion machine’ and ‘to make beer’ are such action descriptions, but it is impossible to perform the former action, and only some people know how to perform the latter. A routine is an action type an agent can choose to perform in order to achieve a certain result; for example, a brewmaster is someone who has mastered routines for making beer. According to Krister Segerberg (1985, 188), “to be able to do something is to have a routine available. To deliberate is to search for a routine.” For example, an act of separation necessary for making a stone tool can be performed by employing different techniques of routines. In hard hammer technique, a core is struck with a hard stone hammer to

cause flaking. In soft hammer technique, the hammer used is softer then the core, for example, a piece of wood or bone. Large core stones can be flaked by hitting them against a stationary anvil stone; this is called the anvil or block-on-block technique. The bipolar technique is a combination of the hammer and anvil methods: the core is set on an anvil and hit from above with a hammerstone. (Toth and Schick 2000, 670.) The evolution of technology consists partly in the development of new, more effective routines for performing productive actions, partly in the development of new artifact types and forms and new tools for making artifacts. (Cf. Petroski 1992a, 1992b.)

Oswalt developed his taxonomy for relatively simple physical (material) artifacts. The production of more complex artifacts, including biological artifacts and abstract artifacts, can be analyzed in similar ways. For example, in DNA technology DNA sequences that are not found in nature (artificial recombinant molecules) are created by the methods of cutting and joining DNA molecules; that is, by separation and conjunction. To introduce new genetic material into a cell, a detached DNA sequence is introduced into a vector, for example, a virus, which can be used as a vehicle for transmitting the passenger DNA into the intended host cell. Thus the routines used in recombinant DNA technology involve sequences of several operations of separation and conjunction. (Primrose and Twyman 2006, 16, 36-54.) In the era of genetically modified organisms, animals and their parts are no longer made exclusively by the nature, as in Aristotle's time.

An abstract artifact, for example, a text, is made by producing an instance of a text which can be copied (that is, replicated) to produce additional instances of the same text. A text is

composed by successive acts of joining, deleting, and replacing words, that is, by acts of conjunction, separation, and reshaping. In the study of belief systems and other information systems, philosophers often treat them as if they were artifacts or tools made for certain epistemic purposes, for example, for giving satisfactory answers to an inquirer's questions or for helping to find answers to new questions. (Hilpinen 1995, 136.) Belief systems are often thought of as being representable by a set of accepted propositions, codified by a set of sentences. They are changed by adding new propositions to the set (expansion), by deleting propositions from it (contraction), or by replacing propositions by other propositions (revision by replacement). (Levi 1980, 25-26; Gärdenfors 1988, 47-48.) These operations are analogous to the acts of conjunction, separation, and reshaping. DNA sequences, texts, and sets of propositions (sentences) are *discrete* objects, made up from discrete units, and it is therefore possible to analyze any revision (reshaping) as a succession of acts of separation and conjunction. In this case separation and conjunction are the only *indecomposable* operations. (Cf. Levi 1984, 125; Gärdenfors 1988, 68-69.) This does hold for artifacts in general.

An intentional modification of living beings does not necessarily require direct manipulation of the organisms themselves, but can be carried out by changing and controlling their environment. This way of modifying an organism can be regarded as a form of reshaping, as *adaptive* (environmental) *reshaping*. It is based on the natural adaptive mechanisms in organisms, but can also be experimentally induced. The resulting organisms resemble artifacts in being artificially modified for certain purposes. (See Elena and Lenski 2003; Suzuki and Nijhoff 2006; Conrad et al. 2011.)

V

The St. Gotthard rail tunnel is an artifact built in the 1870's through a mountain range called Saint-Gotthard Massif in Switzerland. It was made by removing rock and earth from the mountain; thus we can say that the production method used was the reduction of Gotthard Massif, and Gotthard Massif is the parent object of the tunnel. The tunnel was made by detaching a part of the mountain from it, but the detached part did not become the artifact, the tunnel; therefore the artifact cannot be said to have been made by detachment. The detached part is the residue of the production process; the tunnel itself remains a part of the parent object, the mountain. Unlike a branch of a tree, the tunnel is not a detachable part, but a *dependent* part in the sense that it could not exist independently of the mountain. Detachable parts of a parent object, for example, the leaves of a tree or the wheels of a car, can exist independently of the parent; a wheel of a car does not lose its identity when it is removed from the car, but a tunnel, once built, is inseparable from the mountain. Dependent parts of objects are also called *moments*. The distinction between moments ("Momente") and independent parts or "pieces" ("Stücke") was made in this way by Edmund Husserl, who used the expression 'part of an object' to refer to anything that can be said to be *in* the object, or be present in it (Husserl 1913/2001, Investigation III, §2, 5). The dependent parts (objects) of a given parent object are said to be *founded* on the parent, and the parent object is called the foundation or fundament ("*Fundament*") of its dependent parts. The fundament of dependent object may also be called its substrate. Dependent

objects require a foundation (*Fundierung*). (Husserl 1913/2001, Investigation III, §14, 25; Simons 1987, 294-304.) The Gotthard Massif is the foundation of the St. Gotthard rail tunnel.

Another example of an artifact which is a dependent object ("moment") is a knot. Knots are made and used for many purposes; for example, they are used in sailing, fishing, mountain climbing, and are also made for decorative purposes. Peruvian Incas developed sophisticated representations of numbers by knotted cords called *quipus*, and used them for computation and for storing statistical information and astronomical observations. (Ascher and Ascher 1981, 13-35, 81-155; Turner and van de Gried 1996, ix-xi; Christensen 1996, 75-81; Urton 2003.) The foundation of a knot is a knotted cord or cords; a knotted cord is an independent object, but knots could not exist without the cord. Complex artifacts with knots, such as the quipus, are produced by reshaping and conjunction.

Wells and pits are also dependent artifactual objects. An ant lion larva's sand pit is an example of a dependent object which is an animal artifact (i.e., an artifact in Gould's sense); its function is to trap ants and other insects for food; thus it is part of an ant lion's "food-getting technology". (Lucas 1989; personal observations of ant lions.) An ant lion's pit is founded on the sandy ground around the pit, and it is made entirely by reshaping the sand. Other pits and wells are made by the reshaping and reduction of the foundation (the substrate), and in some cases by conjunction as well, when for example stones or other supporting objects are added to the inside of a well. In such case some independent objects become detachable parts of a dependent artifactual object. This holds for the St. Gotthard rail tunnel; a railway tunnel does not

consist of the tunnel (a dependent object) alone, but contains as its parts some supporting structure and a railway track or tracks. These parts of the tunnel are independent parts or pieces which can be separated from it. Thus a dependent object can have independent objects as its parts.

Anthropologists and archaeologists have sometimes expressed the difference between independent and dependent objects as the distinction between *portable* artifacts and *nonportable* artifacts or *features*. (Oswalt 1987, 94; Dickson 1996, 74.) The latter are "nonportable units, facilities, or artifacts that cannot be removed from their matrix without destroying their integrity." (Dickson, *loc. cit*.) For example, roads and tunnels are features their environment. All portable artifacts are independent objects, and all dependent objects can be described as features of their substrate (matrix) or environment. Some independent artifactual objects, for example, buildings, can also be described as "features" of their environment, and would not usually be regarded as "portable" in the ordinary sense of the word, but they are portable (or transportable) in the present quasi-technical sense. For example, the medieval Spanish monastery cloister in North Miami Beach was built in Segovia, Spain, in the 12th century, and later disassembled, transported to the United States, and reassembled in North Miami Beach in the 1950's. In fact, an entire town can be regarded as a transportable object. The Swedish town Kiruna, about 140 km north of the Arctic Circle, sits directly above an extremely rich iron ore deposit, and in 2004 the executives of the Luossavaara-Kiirunavaara AB mining company (LKAB) proposed to the townspeople and their representatives to have the town moved in order to make possible the mining of the valuable ore. Since the town is dependent on the mining industry, the townspeople

agreed to LKAB's request. The town is being relocated, little by little, with a time horizon until 2100. This means that some historic buildings will be disassembled and then reassembled in a new location. (Miller 2011; Kinder 2014; Kiruna 2014.)

VI

Following Oswalt (1973, 1976) and Beck (1980), the acts of artifact production have been divided above into four basic action types: *separation*, *reshaping*, *conjunction*, and *replication*. Often an artifact resulting from a separation can be said to have been made by *detachment* or by *reduction*. If the intended artifact can be described as a detached (independent) part of the parent object, while the remainder retains the sortal identity of the parent, the artifact is a product of detachment, but if the parent becomes an artifact by the separation of some part or parts from it, it is a product of reduction. As the examples in the preceding section show, separation and reshaping can also produce artifacts which are dependent parts of the parent object. In such cases the parent becomes the foundation of the artifact.

On the basis of a number of productive action types $\mathbf{A} = (A_1,\ldots, A_i,\ldots, A_n)$, an artifact can be defined quasi-inductively as any object that has been intentionally produced by means of the actions $A_i \in \mathbf{A}$. The intentionality of production may here be regarded as a requirement for the action types themselves instead of the products, the resulting artifacts. In earlier papers

(Hilpinen 1992, 60-61; 1993, 158-159; 2004) I have suggested that to make an artifact, the maker's productive intention must contain some sortal ("substantival") description or type-description which determines the identity of the intended object. As was noted above, such a description can be a count noun or a mass term. In addition to a sortal description, the author's productive intention should contain other ("adjectival") descriptions which define the intended character of the object. Moreover, an object is an artifact made by an author only if its existence and some of its properties depend on the content of the author's productive intention, and if the author's productive activity has some degree of success. These conditions can be formulated as follows (Hilpinen 1992, 61-62, 65; 1993, 159-161; 2008):

(Int) An object o is an artifact made by an agent (author) R only if R's productive intention contains a description of the intended character of o, including some sortal description which defines the artifact kind (type) of the artifact..

(Dep) An object o is an artifact made by R only if the existence and some properties of o depend on the content R's productive intention.

(Suc) An object o is an artifact made by R only if o satisfies some type-description (sortal description) included in R's productive intention.

(Acc) An object o is an artifact made by R only if R accepts o as satisfying some sortal description in R's productive intention.

The thought behind (Suc) and (Acc) is that if the maker's attempt to make an object of a certain kind fails in every respect and is regarded as a failure, he has not produced a proper artifact, but only "scrap" or residue. The success condition is suggested by Aristotle's statement that art is "a state concerned with making, involving a true course of reasoning, and lack of art on the contrary is a state concerned with making, involving a false course of reasoning." (*The Nicomachean Ethics*, 1140 a 20-23.) The author R may be an individual author or a cooperative group; in the latter case some member or members of the group should accept the object as a completed artifact. The acceptance condition may be satisfied while the success condition fails. An author may accept a product as a K-object when it is not that; in such a situation the author may be said to have reasoned "falsely".

Conditions (Int), (Suc), and (Acc) hold for stereotypical examples of artifacts, artifacts made for some purpose. In the many cases the author's intention is to make an object whose properties make it good for the intended purpose, the "good-making" properties of the artifact. (Cf. von Wright 1963, 19-22.) However, if artifacts are defined by means of productive action types in the way suggested above, these conditions need not always hold, at least not in the above form. For example, an agent may make a conjunctive artifact by intentionally joining various pieces together without having any sortal description or other "intrinsic" properties of the resulting product in mind. He may simply be experimenting or playing with some materials available to him, to see what he might be able to make out of them. In such a case (Int) should be reinterpreted as the condition that the artifact maker has the intention to join the pieces together,

or, in the case of separation and reshaping, the intention to perform such actions. The Success Condition is replaced by the condition that the agent is able to fulfill his intention to perform the productive actions in question; in this case the actions may be said to be based on a "true course of reasoning". The Acceptance Condition becomes the requirement that the author (or one of the authors) believes that the action has been completed. The author and other persons may afterwards describe the artifact by means of some general description, for example, 'contraption' or 'assembly'. If the author has accidentally produced an object that can serve some purpose, for example, if it is used as a decorative object, it can receive a sortal description on the basis of that purpose. The Dependence Condition should hold both for the artifacts and the residue of the productive activity, regardless of how the concept of artifact is defined.

Here, as in other cases, an object made by a single act of detachment represents a minimal case of artifactuality. If someone separates a branch from a tree because he likes its shape and carries it around without any reduction or modification, we would probably not say that he has made a new object (an artifact). If a person removes a branch from a tree or a bush only to be able to pass through a thicket, the action is not a productive action, and no new object has been made. (The situation is different if several branches and shrubs are removed in order to create a path through a dense forest. The resulting path is an artifact, a dependent object whose substrate consists of the ground and the forest around it.) To make an artifact, the author must have a productive intention and his attention must be focused on the intended product of his actions. Intentional action is usually performed for some reason (Anscombe 1963, 9-11; Millar 2002, 113), and in artifact production an agent's reason is to make an object, usually because he wants

to use the intended object for some purpose, or perhaps simply because making things pleases or interests him.

Acknowledgments

The work on this paper was supported by a Cooper Fellowship, University of Miami, and a sabbatical leave. An earlier version was presented as a Cooper lecture at the University of Miami on November 15, 2011. I wish to thank Traci Ardren, Rod Gillis, Robert Halberstein, Anneli Hilpinen, Monica Morrison, Vesa Olkkonen, and Wendell Oswalt and for correspondence and discussions on the topic of this paper.

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