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Functions, Function Concepts, and Scales

Properties like mass and temperature can be ordered on metrical scales. A property like hardness can perhaps only be ordered on an ordinal scale.[1] Geometrical shapes seem to admit ordinal scales only in relation to specifically chosen families of shapes. The main claims of this paper are

1. that there is a similarity between such scale conceptualizations and function concepts;[2]
2. that this similarity makes a non-Darwinian (but nonetheless both non-anthropomorphic and non-causal) concept of function philosophically and scientifically respectable.

It will turn out that there are good reasons why medical and biological scientists have continued to speak of functions in a seemingly old-fashioned, teleological way. Perfect functioning is something like a standard unit (for example the standard meter) in a metrical scale.

1. Introduction: the process sense of function

Ordinary functional statements are explicitly or implicitly relational statements.[3] This is true independently of whether the statement is about parts of organisms ("The function of the heart is to pump blood"), about parts of machines ("The function of the cylinder piston is to transform the explosion of the air-fuel mixture into a mechanical movement"), or about simple tools ("The function of the screwdriver is to fasten and extract screws"). In order to perform its function, a heart has to be related to a body, a cylinder and its piston to a combustion engine, a screwdriver to a hand and a screw.

Often, functional statements are given an explicitly teleological form: "The heart pumps *in order to* make the blood circulate," "The cylinder piston transforms the explosion of the air-fuel mixture into a mechanical movement *in order to* make the vehicle move," "The screwdriver is used *in order to* fasten and extract screws."

In the modern philosophy of functions there are two main camps. First, there are the reductive naturalists who claim that talk about functions should be eliminated in favor of causal talk commonly involving appeal to the notion of natural selection.[4] Second, there are the non-reductive naturalists, who claim that talk about functions is allowed where the function (purpose, *telos*) in question is not regarded as an internal property of the functional entity, but rather as something externally assigned by human beings.[5] From the latter point of view, the term "function" may be said to combine two senses: "the cause-effect sense" and "the assigned purpose sense."[6]

I will try to show that the concept of function should be regarded as involving also a third, process sense. The term "function" when used in this third sense denotes a certain kind of four-dimensional shape that can be called a process shape. I will then show how such shapes can be ordered in a way that is similar to the orderings involved in our use of scales in science and technology. Hence the title of this paper: "Functions, Function Concepts, and Scales."

2. Five neglected aspects

Not everything can be dealt with in a single paper. In particular, there are five aspects of functions that I have here chosen to neglect. First, many functional entities are multi-functional; even if their name refers to one function only.[7] This fact is disregarded in the analysis that follows, since in order to understand multi-functionality, one has first to understand the single function case.

Second, when the function of a functional entity needs to be described, there are often some different but hierarchically related descriptions available. Is the function of the heart to pump blood, to make the blood circulate, or to keep the body alive? The same phenomenon arises in relation to actions. Example: if I lift my arm and put a glass of water to my mouth am I drinking water or slaking my thirst? In the philosophy of action there has been a discussion about this so-called "accordion effect" and about what might constitute a "basic action".[8] This discussion is equally meaningful in relation to the concept of function, but it will not be taken up here.[9]

Third, the end or purpose of a function can be regarded either as being internal to the functional entity, and thus as an end in itself, or as a merely intermediate end, i.e., as a means to something else. In this paper only functions as *means* will be discussed. I started this paper by saying that *ordinary* functional statements are relational statements. I can now add: and only such ordinary statements will be considered.

Fourth, for reasons of simplicity I will often speak of functions without any further qualification. However, the analysis claims validity only in relation to the functions of pure material objects. This is quite a restriction, since symbolic entities such as traffic signs have functions, too.

Fifth, one might say that functional entities such as security and safety devices (e.g., fire alarms) differ from screwdrivers, pistons, and hearts by being preventive rather than productive. Fine-grained distinctions such as this are neglected also.

3. The screwdriver, its function, and its state of functioning

As foil and point of departure, I will use John Searle's analysis of functions in his *The Construction of Social Reality*. Searle is a non-reductive naturalist. He rejects the reduction of functions to some kind of causes, but he has not recognized "the process sense" of functions. Applied to the case of the screwdriver, his analysis says that the function consists in "some causal processes together with the assignment of a teleology to those causal processes."[10] Two levels must then be distinguished:

1. a hand causes the screwdriver to rotate and to move forward in a certain direction, and the screwdriver, in turn, causes the screw to rotate and penetrate into something;
2. human beings collectively assign a purpose to the fastening of the screw.

Level 2 makes the existence of a function a social fact. Among natural or "brute" facts there are no functions.

A screwdriver has a function. When we use it, we put it into a *state of functioning*; when we are not using it, the screwdriver has its states of functioning only as the dispositional property to be able to be in these states. In (its state of) function(ing), the screwdriver participates in a process, namely a certain characteristic movement. In other words, it is in a state of being involved in a process. Is this not a somehow contradictory account? No, it is not. On the contrary, it has the best of ancestors. According to Newtonian mechanics, for a long time regarded as the prototype of what a scientific theory should look like, a thing that is moving with a constant velocity is in a *state of motion*; i.e., it is in a state of changing its place. In the concepts "state of motion" and "state of functioning", the usual contrariety between the concepts of state and of change or process is set aside. Instead, a necessary connection is inserted between states and changes/processes: no state of motion without some change of place, and no state of functioning without some process.[11]

According to Newtonian mechanics, one might well say that a thing that can move but is at rest has the dispositional property of being able to be in a state of motion.[12] And it is in just this way that one can say that an entity *has a* function but is not functioning; it then has the dispositional property of being able to be in a state of functioning.

When we see a screwdriver, then from the ontological perspective we see a material thing that retains its identity over a certain period of time. It retains this identity even if some of its states (e.g., being at rest), powers (e.g., being capable of resisting pressure), or qualities (e.g., mass, volume, color, shape) change. Processes unfold themselves through their successive temporal parts. Enduring entities like screwdrivers, in contrast, have no temporal parts and neither do their states, powers, or qualities (in what follows, I will denote the latter by means of the umbrella term 'properties'). A property either stays the same (endures) or is exchanged for another property; a property, unlike a thing, cannot itself be a bearer of changes.[13]

Consider the following thought experiment. We start by imagining a hand with a screwdriver that drives a screw, and then – in imagination – we remove both the hand and the screw but continue to imagine the same movement of the screwdriver. We are then imagining a certain three-dimensional body making a certain movement in empty space. The idea is that the situation to be imagined here is such that the question "Why does the thing move?" makes no sense. It is by definition disregarded, in the same way that dynamics is disregarded in physical kinematics. The case of kinematics tells us that the relationship between place, time, movement, velocity, and acceleration of moving bodies can be, and historically has been, investigated with the causes of the movements disregarded. Here I want to argue, similarly, that certain facts about functions can be investigated while certain associated causal relationships are disregarded.

In order to see what has been neglected in previous analyses of functions, still another imaginative leap has to be performed. All those properties of our screwdriver that are non-essential for its function should be removed, too. What is left are then its central functional properties: first, its shape-with-size (shape, for short, in what follows), and, secondarily, the hardness that allows the screwdriver to retain this shape. I will focus here exclusively on shape. Every type of matter that creates the required hardness without too great a cost in weight will fulfill the hardness requirement.[14]

The image we now have before us is of a three-dimensional shape that performs a rotating movement forward. This movement of the whole shape has to be regarded as a process. Its existence is dependent on that of the screwdriver. The screwdriver is always a property-bearer, but sometimes it is a process-bearer as well.[15]

When the movement spoken of is represented in an abstract space with three spatial and one temporal dimension, it will constitute a specific four-dimensional shape bounded by a specific time interval.[16] As a circle in ordinary Euclidean geometry is necessarily two-dimensional (it can exist in a surface but not in a straight line) and as a sphere is necessarily three-dimensional (it can exist in a volume but not in a surface), so the shape associated with the functioning of the screwdriver is necessarily four-dimensional. I will refer to it henceforth as a *process shape* or sometimes also a *four-dimensional shape*.[17]

The distinction between entities that lack and entities that have temporal parts is as applicable to entities from which certain features have been abstracted away as it is to concrete entities in real spacetime. The process shape spoken of is then an entity that necessarily has temporal parts. If one thinks away even one small part of the temporal extension of the process shape, then its identity is lost in the same way that a determinate rectangular shape loses its identity if a cut is made in one of its edges.

With respect to the four-dimensional shape just described, I will defend three claims:

(i) that the realization of this shape, or a very similar one, is a necessary condition of the screwdriver's functioning;

(ii) that this shape can be analyzed independently of any causal process in which it is involved;

(iii) that this shape does not necessarily have an assigned purpose.

About (i): If the screwdriver were not able to give rise to or to instantiate the shape spoken of (or a similar shape; for simplicity's sake I will mostly ignore this complication in what follows), it would not be able to perform its function. This much, I hope, is clear.

About (ii): When the screwdriver is functioning as a screwdriver, then there has to be something that causes it to realize the screwdriving movement. Therefore, the shape in question is both the effect of a causal process (standardly: a movement of the hand) and a cause in its own right. Two further four-dimensional process shapes are thus involved, of the hand and of the screw. In themselves, however, no four-dimensional shape is either cause or effect. It is, just, a *shape*. The process at hand can thus be analyzed in such a way that we abstract from those features in virtue of which it participates in a chain of events related together by causality.

About (iii): When a screw has been fastened to a board by means of a screwdriver, then there is an *enduring product*, the screw-board combination, but also a *non-enduring product*,[18] namely the four-dimensional token shape that is created by the movement of the screwdriver.[19] All accomplished processes are non-enduring products, but some of them yield enduring products, too. It is for the sake of the enduring product that the screwdriver is assigned a purpose, not in virtue of the four-dimensional shape that is realized along the way.

And what does all this mean? First, it means that the functionally necessary process shape that has the screwdriver as its bearer is, taken in and of itself, identical neither with a causal process, nor with a teleological process, nor with a mixture of such processes. The neglect of this fact I will call *the first oversight in the modern philosophy of functions.*

Second, it means that functional statements like "The function of the thing lying there is to fasten and extract screws" have an implicit reference to a range of four-dimensional shapes (reminder: for simplicity's sake I often speak as if the range mentioned consists of one shape only). These are entities which can be described in the same way as ordinary shape statements describe two- or three-dimensional shapes, i.e., quite independently of the objects (for example hands or screws or boards) which instantiate them. In other words, at least part of what makes true a statement such as "The function of the screwdriver is to fasten and extract screws" is both non-causal and non-teleological.

4. The cylinder piston, its function, and its state of functioning

When a cylinder piston is (in a state of) functioning, it is located within a cylinder that is part of an engine that is running. The explosion of the air-fuel mixture is to the piston what the movement of the hand is to the screwdriver, and the movement of the crankshaft is to the piston what the movement of the screw is to the screwdriver. As with the functioning of the screwdriver, so also here: the piston's functioning can exist only as a relation between at least two other spatiotemporal entities.

A cylinder piston at rest in an engine at rest still has its function. But what about a piston in a broken cylinder, or a piston on a shelf in a warehouse? In my opinion, both have the dispositional property of being able to be in the state of functioning, too. But this is of no crucial importance for my analysis. The important thing is that, as with the screwdriver, even a piston taken out of all functional contexts can still be imagined as performing the movement which it performs when functioning – a movement up and down which during a certain time interval creates as a non-enduring product an instance of a certain determinate four-dimensional shape.

In all essential structural respects, the four-dimensional shape associated with the piston is like that associated with the screwdriver. (i) It is a necessary condition of the piston's functioning; (ii) it can be analyzed independently of any causal process in which it is involved; and (iii) it does not necessarily have an assigned purpose. The statement "The function of the cylinder piston is to transform the explosion of the air-fuel mixture into a mechanical movement" is thus again made true in part by something that is both non-causal and non-teleological. The enduring piston is always a property-bearer, but sometimes it participates in a process and becomes a process-bearer as well.

5. The human heart, its function, and its state of functioning

When a heart is in a state of functioning, it is situated within a living body. On the high level of abstraction of our present discussion, the stimulation of the heart by the sympathetic and parasympathetic nervous systems is to the heart what the movement of the hand is to the screwdriver, and the contractions and expansions of the heart are to the blood what the movement of the screwdriver is to the screw. As with the functioning of the screwdriver and cylinder piston, the functioning of the heart exists as a relation, a relational process between at least two other spatiotemporal entities of highly determinate sorts.

In a famous passage, Aristotle says that "the eyes or the hands of a corpse are not really an eye or a hand, they are so only in name, for they will be unable to perform their function."[20] In the time before heart transplants, the same thing could have been said about the heart. Even today, a heart on the pathologist's shelf cannot, in contradistinction to a screwdriver and a piston taken out of their functional contexts, truly be ascribed its state of functioning as a dispositional property. Why not? Because, to mention only one thing, the soft matter of the heart does not keep its normal shape. In the future, however, there may be artificial hearts that sustain their shape the way solid objects do.

The heart when functioning instantiates, among other things, a sequence of changing volumes and shapes. This sequence is normally unrealizable when the heart has been taken out of the body. But still it is possible to *imagine* an isolated heart performing the movements associated with its functioning – a contracting movement inwards and an expanding movement outwards – movements which, of course, during a certain interval of time create as a non-enduring product a certain determinate four-dimensional shape.

Thus in the case of the functioning of the heart, too, it is possible to make out a four-dimensional shape that is like those of the screwdriver and the piston in the relevant structural respects. That is: (i) its realization is a necessary condition of the heart's functioning, (ii) it can be analyzed independently of any causal process in which it is involved; and (iii) it does not necessarily have an assigned purpose. It is an instance of a process shape. The functional statement "The function of the heart is to pump blood" is then made true in part by an entity that is both non-causal and non-teleological. In its state of functioning, a heart is always both a property-bearer and a process-bearer.

6. Functional concepts and ordinal scales

In each functional statement it is taken for granted that a described function can be performed more or less well in relation to a goal or purpose that is often only implicitly specified. A functional statement implicitly contains a hypothetically normative statement. It says: *if* one wants to reach this goal and *if* one can choose the means and *if* one wants to do so in an efficient way, *then* one ought to choose the entity that is the best possible means to reach the goal. If the goal consists in having an already on-going process continue to go on well (e.g., one's life), then the hypothetical normative statement reduces to: *if* one wants to reach the goal, *then* one ought to try to keep the means in the best possible condition. Applied to my three examples this yields:

(a) *If* one wants to use a certain kind of screw to fasten something and *if* one can choose the tool and *if* one wants to be efficient, *then* one ought to choose the kind of screwdriver that is the best possible means to fasten this screw.

(b) *If* one wants to transform the explosion of the air-fuel mixture in the cylinder (in the engine of one's car) into a mechanical movement and *if* one wants to be efficient, *then* one ought to try to keep the piston in the best possible condition.

(c) *If* one wants something that pumps the blood in one's body and *if* one wants to be efficient, *then* one ought to try to keep one's heart in the best possible condition.

Quite obviously, a factually existing state of functioning need not be the best possible such state; we talk of entities functioning subnormally, and even of dysfunctional and malfunctional entities. Nor need the best possible functioning be a case of perfect functioning.

There are, in other words, "degrees of functioning," and in order to come to grips with this issue we need to consider some further thought experiments.

Imagine that we are perceiving, veridically, a world containing only a single stick L in an empty space. Can we then say truly either that "L is long," that "L is short," or that "L is middle-sized"? From a superficial point of view, all three assertions might be said to ascribe to L a certain corresponding monadic property, but from an ontological point of view there are in such a world no monadic properties of the given sort. There is of course one pertinent monadic property: L does have some determinate length; but this determinate length is in itself neither long, nor short, nor middle-sized. It would be so only in relation to other determinate lengths, and there are by assumption no such lengths to compare it with. Of course if, in the situation envisaged, we are capable of imagining things, then each of us might compare the perceived stick with imagined sticks; but even then, since we cannot compare the products of our imagination, there will still be no intersubjectively apprehendable and communicable properties of being long, being short, or being middle-sized. A thing taken out of all real contexts of comparison is neither long, nor short, nor middle-sized. In a one-thing world L has a length (an instance of a certain monadic property), and as minds perceiving this length, we could give it a name. But no more.

Let us now move to a two-thing world with sticks L and S. Here we perceive in an otherwise empty space: L and its determinate length; S and its determinate length; and, thirdly, the length *difference* between L and S.[21] We can then say truly both "L is longer than S" and "S is shorter than L." Both statements are made true by the same ontological relation, the length difference between L and S.[22] As shorthand versions of these statements we may of course then use "L is long" or "S is short," too.

In the situation envisaged, we discover – rather than invent – the length difference between L and S. The difference is there independently of whether or not we make a length comparison between L and S. The relation described by "L is longer than S" exists necessarily as soon as both its relata exist. In this respect it is an instance of a whole class of relations, which, following Armstrong, I will call internal relations.[23] In my view (but not Armstrong's), such relations belong to the ontological furniture of the world. That is, they "add to being" even though they have a kind of existence that is more shadowy than that of substances and some monadic properties. Like shadows, such relations can be seen but not really touched.[24]

One way in which internal relations differ from so-called external relations, such as the relation of standing at a certain distance apart, is that they lack a mediating tie in relation to their relata; they are, so to speak, epiphenomenal; they "come for free." When two things stand in an external relation like "L is at a certain distance from S," then the spatial distance between L and S is the mediating tie between them, and this distance does not come for free when once we know the properties that inhere in L and S. It is because of this contrast that philosophers such as Armstrong have concluded that internal relations are "no addition of being."[25] This, I think, is false. Reductive naturalists like Armstrong seem to conflate being an epiphenomenon with making "no addition of being." But to say that internal relations are discovered, rather than invented, is to say precisely that they have some kind of mind-independent existence. Certainly, they are at least epiphenomenal entities: they exist necessarily when all their relata exist, but they have no direct causal powers of their own. From a non-reductive naturalist point of view, however, in which even intentional phenomena like perception are taken into account, even epiphenomenal entities can have causal powers. Thus for instance since, as I have pointed out, some internal relations can be *perceived*, it follows that they can influence perceiving agents.

Let us now apply the concept of internal relations in a normal many-thing world. In this world we can easily discover three-term internal relations such as "x has the same length as y but not as z" and "x resembles y more than z in regard to length." With the help of such internal relations it is possible to construct an ordinal scale for length and to start speaking about objects being shorter or longer than others in the way we are used to doing.[26] Note that every ordinal scale presupposes a distinction between a determinable (what kind of entities the scale represents) and its determinates (what each specific value on the scale represents).

The existence of a large number of internal relations constituting an ordinal scale of lengths allows us to talk also about fictional lengths. One can then imagine things that, if they were real and their lengths compared with the lengths of other real objects, would have to be placed between two pre-existing determinates in the ordinal scale. Therefore, all the values (points, labels) on an ordinal scale need not denote actually existing entities.

And these remarks about creating ordinal scales can be applied not only to those one-dimensional shapes which are determinate lengths but to other sorts of shapes, too. This means in particular that there are internal relations among determinate process shapes. The neglect of this fact I will call *the second oversight in the modern philosophy of functions*.

Already in the case of two-dimensional shapes, it seems to be impossible to construct a single ordinal scale along which even all possible shapes can be ordered in sequence. Only for certain kinds of shapes, such as ellipses with one axis fixed, does such an ordinal scale seem to be possible. And when we move to three- and four-dimensional shapes then naturally the complexity grows, and here only much smaller subsets of shapes can be plotted on an ordinal scale.[27]

Ordinal scales have nice formal properties. However, just as logicians have extended the traditional concept of formal logic in various ways, and now allow such things as deviant logics and fuzzy logic, so I propose that philosophers of science should now widen the concept of scale. For instance, one might define a concept of "improper ordinal scale" as follows. An ordinal scale is improper with regard to its determinable and its determinates *if and only if*:

(a) one single ordinal scale for the determinable cannot be constructed (true already for two-dimensional shapes);

(b) for at least one subset of determinates an ordinal scale can be constructed (true for two-dimensional shapes);

(c) at least two different sub-scales represent different dimensions of the determinable in question (compare the dimensions of length and height for rectangles);

(d) the determinable lacks a clear boundary; this implies that there are entities in relation to which it seems to be a matter of convention whether they should be regarded as falling under the corresponding conceptual determinable or not.[28]

Four-dimensional shapes when taken as a whole do not constitute a determinable with which an improper ordinal scale can be associated. This is because, while they conform to the requirements (a), (b), and (c), they do not satisfy (d). Hopefully, (a) and (b) require no comment; with respect to (c) the ordinary spatiotemporal dimensions play the role of dimensions of shape-variation. The (d)-requirement is not fulfilled, since being a four-dimensional shape *is* a well defined determinable; there is no gray area between being four- and being three-dimensional. What is remarkable, however, is that each specific kind of function determines a realm of four-dimensional shape determinates that taken in themselves do fulfill all of the four requirements. That is to say, each given kind of function can at least be connected to an improper ordinal scale. Let me explain.

What I have called the screwdriver-function, the piston-function, and the heart-function, can each be considered as determinables in relation to all the specific process shapes that constitute the different degrees of functioning of the corresponding objects. With respect to these *function determinables* (and in contradistinction to the determinable: four-dimensional shape in general) there are no bona fide boundaries. The limit between functioning badly and not functioning at all has to be drawn by fiat.

The conclusion of this section is: there is an important similarity between ordinal scales and function concepts. The neglect of this fact I will call *the third oversight in the modern philosophy of functions.*

7. Function concepts, metrical scales, and scales marked by prototypicality

The statements “L is 20 cm long” and “S is 10 cm long” entail the statement “L is longer than S.” Of course, this and similar logical facts show that in a theoretical system that contains an axiom which says that there is a metrical scale of lengths, one can deduce that there is an ordinal scale of length as well. However, this fact by no means shows that ordinal scales are ontologically and/or epistemologically dependent on metrical scales. In fact, it is the other way round: metrical scales are both ontologically and epistemologically dependent on ordinal scales. If one wishes to construct a metrical scale one has to know how to construct the underlying ordinal scale. A metrical scale of lengths presupposes both the existence of an ordinal scale and a repeatable measuring operation that can sustain the pertinent numerical values.

All statements of the form “L is x cm long” are relational. They relate L in one way or another to a standard meter. Once upon a time this standard meter was kept in Paris. Today, it is theoretically defined, in a way that makes it reconstructible in different physical laboratories. Each length instance stands in mind-independent internal relations to all other length instances, including the length of the standard meter. One might say that the world is covered by a tightly woven web of such thin relations.[29] All linguistic acts are selective and mind-dependent. The assertion “L is 20 cm long” picks out the determinate length of L and relates it directly to the length of the standard meter; but indirectly it relates it to all other length instances, too. Note that even though the length instance of the standard meter is a mind-independent property, the fact *that this* instance is the standard meter is a mind-dependent social fact. This duality of the standard meter will be used to shed light on functions and function concepts, too.

Consider the statement “L is 20 cm.”[30] This makes the distinction between determinables and determinates grammatically visible: (i) the expression ‘cm’ indicates the existence of the determinable *length*, and (ii) the expression '20' picks out one specific determinate of this determinable. However, (iii) the expression 'cm' harbors a reference to the standard meter. It makes it clear that one centimeter is one hundredth of the standard meter.

Consider now the statement "L is a rather good screwdriver." To be a screwdriver is to have the function of fastening and extracting screws; and since this function can be performed more or less well, (i) the use of the expression "screwdriver" indicates the existence of a certain determinable *functioning in such a way as to drive screws*. To say that the screwdriver is "rather good" is (ii) to pick out at least one specific determinate of this determinable. But just as "cm" involves an implicit reference to the standard meter, so (iii) "screwdriver" involves an implicit reference to a state of perfect functioning (or to a range of such states, a complication which, again, is ignored for the sake of simplicity). Focusing, as earlier, on the relevant four-dimensional shapes, we can say that the statement "L is a rather good screwdriver" contains an implicit reference to one particular "perfect" four-dimensional shape. This means that all other determinates of the determinable *functioning in such a way as to drive screws* have a certain (very indefinite) distance-relation to this perfect four-dimensional shape. The latter itself takes on the role of a fundamental standard unit. However, it does this in a quite specific way.

As Eleanor Rosch has stressed, there is an important distinction to be made between logical and prototypical classification.[31] All the well-known scales from the natural sciences are of the logical kind; the function concept, however, is a device for prototypical classification. The idea of a perfect functioning of a certain kind is an idea of a prototype. It is a focal point of reference in relation to which all other relevant instances can be given a rough "distance measure". Where, exactly, the line between extremely bad functioning and non-functioning is to be drawn one neither knows nor cares. I think there are good reasons to speak not only of prototypical classification, but also of prototypical *scales*, and I propose that we henceforth regard many functional concepts as scales of this kind.

A scale marked by prototypicality can have several dimensions; in ordinary speech this manifests itself in our reference to something's being good or bad "in a certain respect". In the case of screwdrivers, there are at least four such dimensions: good and bad *shape*, *size*, *weight*, and *elasticity*.

The use of "cm", "km", etc., involves a reference to a normatively neutral standard unit. It does not imply that if one wants a length, then one ought to get a length that is equal to the standard meter. However, the use of "screwdriver" involves a reference to a hypothetical normative prototype: the perfect screwdriver. It says that *if* you want to fasten a screw and *if* you can choose your screwdriver and *if* you want to be efficient, *then* you ought to choose a screwdriver that is close to the standard norm. The prototypical idea of the perfectly functioning screwdriver is thus a combination of two ideas: (a) it is an idea of a fundamental standard unit (actually a range of such units for different types and sizes of screws, etc.), and (b) it is an idea of a norm.

One can of course distance oneself from the normative conclusions of function talk and concentrate instead wholly upon the quasi-metrical dimension of the matter in hand. I suspect that this is the way functional talk appears to many researchers (not however to practitioners) within domains like medicine. The idea of such a non-normative concept of function is however rarely addressed explicitly.[32] This neglect of the possibilities of fusing and separating the two dimensions of norm and prototypical standard unit I will call *the fourth oversight in the modern philosophy of functions.*

At the beginning of section 3, I presented Searle's analysis of functions, which says that a function consists in "some causal processes together with the assignment of a teleology to those causal processes." My criticism, as should by now be clear, is that Searle overlooks the existence and importance of process shapes and of all that goes together therewith in terms of norms and prototypical standards. I have no objections to his view that where the causal processes involved are natural facts the associated teleologies are social facts. The fact that something is a functional entity is thus a "fused fact": it fuses a social fact with some natural facts. This very same fusion, I now want to insist, is to be found also in the realm of process shapes. For although all the kinds of process shapes spoken of are in themselves natural entities, the fact that one such shape is the prototypical unit is as much a social fact as the fact that a certain rod in Paris is (has been) the standard meter.

8. Pictorial representations of functions

The ontological views that I have put forward may seem to be rather remote from the everyday life of craftsmen, engineers, and physicians; but this impression is misleading. What I have said of four-dimensional shapes is in conformity with the way functions are often represented pictorially, for example in handbooks and manuals. Implicitly, as I will very briefly explain, functions can be represented as four-dimensional spatiotemporal entities even in pictures.

Ordinary pictures are in a certain clear sense two-dimensional, i.e., they are rendered on a surface. Nonetheless, we often see the pictured things as being three-dimensional (though not necessarily as ordinary three-dimensional things). In pictures of functional entities such as pistons, arrows are sometimes inserted that implicitly represent temporal extension. Explicitly, they represent directions of movement, but since there is no actual movement without temporal extension, they represent temporal extension, too. Pictures of a piston inside a cylinder containing two arrows pointing in opposite directions are meant to show that the piston moves up and down *in a certain time interval*. To a picture of a screwdriver one may add one arrow showing the rotating movement and another showing the movement forwards. One can thus truly say that many pictures of functional entities represent them precisely as bearers of four-dimensional process shapes.

9. Conclusion

To say that functional entities have a function is to say either that they have a disposition to be in a state of functioning or that they are in fact in such a state; each state of functioning is constituted by a certain process. Such processes cannot be reduced to either a causal or a teleological process or to any combination of the two. This non-reducibility is due to the fact that such processes involve also certain four-dimensional shapes. The latter can in an incomplete way be ordered, on scales marked by prototypicality. If the prototype of such a scale is also regarded as a normative prototype, then the functions and processes in question have a corresponding teleology. This latter, however, is either purely subjective or it is a social fact.

I conclude by stating once again the four facts that have been overlooked in the modern philosophy of functions:

1. there are four-dimensional shapes (process shapes) that are necessary to the functioning of, for example, many tools, mechanisms, and bodily organs;
2. there are internal relations between such process shapes;
3. there is an important similarity between ordinal scales and function concepts;
4. what looks like a functional norm can also be a fundamental prototypical standard unit; when this is the case, there is an important similarity between metrical scales and function concepts.[33]

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NOTES

[1] The famous Mohs scale is an ordinal scale, but it has been argued that it can be superseded; see H. C. Hodge and J. H. McKay, "The 'Microhardness' of Minerals Comprising the Mohs Scale," *American Mineralogist* 19 (1934), pp. 161-168 (http://www.minsocam.org/msa/collectors_corner/arc/microhardness.htm).

[2] When, in what follows, I speak of scales, I am not talking about scales as concrete particulars like measuring rods and thermometers. I am talking about the underlying conceptual construction.

[3] *Extraordinary* functional statements are statements that ascribe a function-in-itself or purpose-in-itself to something; see section 2, below, "third neglected aspect."

[4] For an overview of standard analyses of functions, including the so-called deductive-nomological, etiological, and intrasystemic analyses, see P. Melander, *Analyzing Functions. An Essay on a Fundamental Notion in Biology*, Stockholm: Almqvist & Wiksell 1997. I agree with Melander's criticisms of these analyses, but not with his own positive alternative, which remains within the reductive framework. According to Melander, all non-anthropomorphic talk of functions in biology can be reduced to talk about either adaptation or adaptiveness.

[5] See e.g. Searle, *The Construction of Social Reality*, New York: The Free Press 1995, pp. 16-19.

[6] See e.g. R. Brown, *Explanation in Social Science*, London: Routledge & Kegan Paul 1963, p. 123.

[7] One might also talk about *occasional* functions, as when a coin is used to unscrew a screw.

[8] See A. White (ed.), *Philosophy of Action*, London: Oxford University Press 1968, especially A.C. Danto's paper "Basic Actions."

[9] I discuss this aspect in my *Ontological Investigations*, London: Routledge 1989, 2nd ed'n, Frankfurt: ontos 2004 , chapter 5, "Actions and Functions."

[10] Searle, *The Construction of Social Reality*, p. 15.

[11] Or, to be more precise, there is no temporally non-infinitesimal state of motion without a change of place.

[12] It should, though, be added that physicists seldom speak this way. They say that a thing is *always* in a state of motion because at rest a thing has the constant velocity (= state of motion) *zero*. Since functions are not quantified, however, it would be odd to say that a functional entity at rest is in a state of zero functioning. Perhaps this difference explains why the analogy that I have made between "state of motion" and "state of functioning" has, as far as I know, not been noted earlier.

[13] Using the endurant-perdurant distinction, one might say that a screwdriver conceived as a mere thing is an endurant property-bearer with endurant properties. An endurant is an entity that necessarily lacks temporal parts; a perdurant is an entitiy that necessarily has temporal parts. For some early views on the distinction between endurants and perdurants, see R. Ingarden, *Time and Modes of Being*, Springfield, Ill.: Charles C. Thomas 1964,

Chapter IV (translation of *Der Streit um die Existenz der Welt* I, Tübingen: Max Niemeyer 1964, §32), E. Zemach, "Four Ontologies," *Journal of Philosophy* 67 (1970), 231-247, and D. Lewis, *On the Plurality of Worlds*, Oxford: Blackwell 1986, pp. 202-220.

[14] To be even more precise: only parts of the shape are truly essential, namely that part where it meets the screws and that part where the application of torque by means of the hand is facilitated.

[15] In more general terms: an enduring thing is always a bearer of instances of property-endurants and it is sometimes a bearer of instances of perdurants.

[16] One can of course define a four-dimensional volume, too; one has merely to integrate the three-dimensional volume of the three-dimensional shape over the life-time of the four-dimensional shape.

[17] Relativity theory and four-dimensionalism in philosophy (which denies the literal existence of endurants) have no monopoly on the concept of four-dimensional properties.

[18] The distinction between enduring and non-enduring products is taken from the paper "Actions and Products" in K. Twardowski, *On Actions, Products and Other Topics in Philosophy*, Amsterdam: Rodopi 1999, pp. 103-132. For more on this Twardowskian distinction, see B. Smith, *Austrian Philosophy. The Legacy of Franz Brentano*, Chicago: Open Court 1994, chapter 6.

[19] An utterance is another very common kind of non-enduring product. The writing of a sentence is a non-enduring product, the written sentence an enduring product. For more details on this, see my paper "Performatives and Antiperformatives", *Linguistics and Philosophy*, forthcoming.

[20]Aristotle, 640b34-641a10 (from *Parts of Animals*).

[21] The view that relations are perceivable can be found for instance in D.M. Armstrong, *A World of States of Affairs*, Cambridge: Cambridge University Press 1997, chapter 6; Armstrong traces it to William James. The view that relations can be objective and not only mind-dependent entities was argued in the early twentieth century by A. Marty; see B. Smith, *Austrian Philosophy. The Legacy of Franz Brentano*, chapter 4.

[22] This view is defended by, e.g, I. Segelberg, *Three Essays in Phenomenology and Ontology*, Stockholm: Thales 1999, pp. 189-90 (from an essay first presented in Swedish in 1947), and D. M. Armstrong, *A World of States of Affairs*, chapter 6.

[23] See D.M. Armstrong, *A Theory of Universals* vol. 2, Cambridge: Cambridge University Press 1978, pp. 85-86. This kind of internal relation ought not be conflated with the kind of relation that the British idealists of the nineteenth century called internal relations. The relata of an Armstrong-internal relation can exist independently

of each other, not so the relata of what might be called Bradley-internal relations; see Johansson, *Ontological Investigations*, chapters 8 and 9.

[24] This is true even for those internal relations between monadic properties, such as the property of smoothness, that can be felt by touching. The relation mentioned in "a is more smooth than b" cannot be felt by touching.

[25] Armstrong, *A World of States of Affairs*, p. 12.

[26] For some classic accounts of different kinds of scales, see Brian Ellis, *Basic Concepts of Measurement*, Cambridge: Cambridge University Press 1968, and Carl G. Hempel, *Fundamentals of Concept Formation in Empirical Science*, Chicago: University of Chicago Press 1952. My presentation, however, contains an implicit criticism of Ellis's and Hempel's view to the effect that an ordinal scale can be constructed with the help of two *two-term* relations, namely what Hempel calls coincidence and precedence. In my opinion, three-term relations are required, since: (i) one might be able to establish coincidence (has the same length as) without being able to establish non-coincidence, but both are necessary for the construction of the scale; (ii) when the scale *has been* constructed, one can from the facts that x precedes y and y precedes z draw the conclusion that x resembles y more than z, but when the scale is still *under construction*, one has already to have the three-term relation "x resembles y more than z" at one's disposal.

[27] My views in this paragraph are partly based on JJ. Koenderink, *Solid Shapes*, Cambridge MA: M.I.T. Press, 1990.

[28] It needs to be stressed that I am here presupposing that there are property determinables in the language-independent part of the world, just as there are conceptual determinables within language. For a defense of this view, see my "Determinables as Universals," *The Monist* 83 (2000), 101-121. Philosophers who regard all determinables as being only conceptual constructs often speak of *domains* instead of determinables, and of *quality dimensions* instead of scales. See Peter Gärdenfors, *Conceptual Spaces. The Geometry of Thought*, Cambridge Mass.: The MIT Press, 2000.

[29] For more on the distinction between thick and thin relations see K. Mulligan, "Relations – Through Thick and Thin," *Erkenntnis* 48 (1998), pp. 325-353.

[30] I disregard the fact that some screwdrivers are good for screwing into wood, others into metal, and so on.

[31] E. Rosch, "Prototype Classification and Logical Classification: The Two Systems," in E. Scholnik (ed.), *New Trends in Cognitive Representations: Challenges to Piaget's Theory*, Hillsdale N.J.: Lawrence Erlbaum Associates, 1983, 73-86.

[32] One exception to this rule is the Swedish histologist I. Täljedal. In the paper “Biologisk funktion,” *Filosofisk tidskrift* 23 (2002), no. 4, pp. 11-17, he claims that several scientists use the concept of “function” in a non-Darwinian but still scientifically useful way.

[33] This paper is an improvement on views earlier put forward in my *Ontological Investigations*, chapters 5, 12, and 14. Members of IFOMIS in Leipzig, Randall R. Dipert, Chris Partridge, and the participants in a workshop in Buffalo were helpful in shaping the final version. The work was supported by the Alexander von Humboldt Foundation under the auspices of its Wolfgang Paul Program.