

The Ontology of Processes and Functions: A Study of the International Classification of Functioning, Disability and Health

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ABSTRACT

The International Classification of Functioning, Disability and Health provides a classification of human bodily functions, which, while exhibiting non-conformance to many formal ontological principles, provides an insight into which basic functions such a classification should include. Its evaluation is an important first step towards such an adequate ontology of this domain.

1 INTRODUCTION

While considerable progress has been made in the development of principles-based ontologies of continuant entities (illustrated above all by the Foundational Model of Anatomy), the ontology of processes remains for a number of reasons in a comparatively impoverished state. This rests in part on the computational difficulties we face in representing time and change. It has to do also with the fact that the boundaries and spatiotemporal locations of processes are harder to define than are those for continuants such as cells or organisms.

The International Classification of Functioning, Disability and Health (ICF)¹ is a classification of bodily functions, structures, and activities salient to the domain of health. Despite a number of shortcomings, the ICF provides a basis for a more coherent ontology of processes and functions of the sort which is needed for advance in biomedical informatics in the future.

We will concentrate here on the treatment of bodily functions within the ICF, using the resources of Basic Formal Ontology (BFO) to formulate requirements for the adequate representation of processes and functions in the future. [1]

2 FUNCTION AND FUNCTIONING

According to BFO, we must distinguish first of all between functions and their realizations or executions (also called *functionings*). The function of your heart is *to pump blood*; this is a power, potentiality or disposition of your heart, whose realization consists in actual processes of pumping. The latter gives rise also to certain non-functional by-products, such as the *thumping* of your heart.

Functions are continuant entities. Like your heart itself, its function *to pump blood* endures identically through time while being realized in a succession of occurrent processes. The function of your heart is a *dependent* continuant, which means that it is dependent for its existence on your heart, which is its bearer or carrier. Just as your heart exists in full at any instant of time that it exists at all, so its function exists in full at any instant of time when it exists at all. Processes, in contrast, never exist in full in a single instant, but rather unfold themselves in a succession of temporal phases. A further reason for the distinction between functions and functionings is that the former can exist without the latter (when functions exist, but in a dormant state). It is the function of each sperm *to penetrate an ovum*, yet this function is realized in only a vanishingly small fraction of the sperm which actually exist.

Unfortunately the distinction between function and functioning is not recognized within the ICF, which defines **Functioning** as “an umbrella term encompassing all body functions, activities and participation”. Both functions and activities, according to ICF, are functionings, and inspection reveals that when ICF talks of *functions* then it is *functionings* that is primarily intended – so that the ICF does not have a clear counterpart of functions as continuant powers or potentials. Nor, correspondingly, does it have a clear distinction between functionings and non-functional by-products or side-effects of the execution of functions. In what follows, therefore, we shall normally substitute the phrase ‘activity / function’ for each occurrence of the word ‘function’ as it appears in the ICF classification.

3 PROBLEMS WITH THE ICF CLASSIFICATION

Major shortcomings of the ICF classification include:

1. **Incongruent classification:** The eight main categories into which Body Activities / Functions are divided within the ICF are: (i) Mental Activities / Functions ; (ii) Sensory Activities / Functions and Pain; (iii) Voice and Speech Activities / Functions; (iv) Activities / Functions of the Cardiovascular, Hematological, Immunological and Respiratory Systems; (v) Activities / Functions of the Digestive, Metabolic and Endocrine Systems; (vi) Genitourinary and Reproductive Activities / Functions; (vii) Neuromuscular and

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¹ <http://www3.who.int/icf/icftemplate.cfm>

Movement-Related Activities / Functions ; and (viii) Activities / Functions of the Skin and Related Structures.

We see that while some activities / functions in the above are distinguished on the basis of the organ system to which they belong, others are distinguished on the basis of the activity itself, which leads to incongruence in the classification (as if we were to define two kinds of people: *people in the Northern Hemisphere*, and *people with prostheses*).

2. Confusion between classes of activities and their qualities or features: The ICF includes the class *consciousness functions* (on our reading: *conscious activity*), with subclasses: *state of consciousness*, *continuity of consciousness*, *quality of consciousness*, and so on. The latter, however, are not in fact subclasses of *conscious activity*, but rather qualities or attributes of such activity (as if we were to classify *fruit* into the subclasses: *apples*, *bananas*, and *shape*).

3. Alignment of function with loss of function: On a reading of ‘function’ as meaning ‘activity’, it is difficult to supply for the term ‘loss of function’ a coherent meaning. It is however nonetheless clear that *loss of function* should not be included as a subclass of the corresponding *function / activity*, as for example in the ICF’s definition of *consciousness*, which reads: “General mental functions of the state of awareness and alertness, including the clarity and continuity of the wakeful state. Inclusions: functions of the state, continuity and quality of consciousness; loss of consciousness, coma, vegetative states, fugues, trance states, possession states, drug-induced altered consciousness, delirium, stupor”. This definition reveals that the ICF is uncertain also as to the distinction between *function / activity* and *quality*.

4. Incorrect classifications: There are many parent-child relations within the ICF in which the child classes are not in fact genuine subclasses of the parent class. An example is: *heart function* subsumes: *heart rate*; *heart rhythm*; *contraction force of ventricular muscles*; *blood supply to the heart*; *heart functions, other specified*; and *heart functions, unspecified*. The rate and rhythm of the heartbeat are neither functions nor activities of the heart, but rather qualities or attributes of such activities. The maintenance of this rate and rhythm qualify as functions / activities, but they are not functions / activities of the heart alone, but also of many other organs. The function of the heart is not the contraction force but rather *to contract* (with corresponding activity: *contracting*), a function that is executed primarily by ventricular and partly by atrial muscles.

5. Incomplete classification: Every classification must in many ways be incomplete. Thus for example no bodily activity / function can be completely divided into its constituent parts unless one is willing to proceed down to the level of activities of electrons and protons. There are some situations within ICF, however, where an activity / function is specified *only* in terms of the anatomical structure which is its bearer, with no representation of what actual function is performed by the corresponding body part. For example,

ICF’s *blood vessel functions* has children: *functions of arteries*; *functions of capillaries*; *functions of veins* and so on (as if one were to describe the functions of a knife as consisting in *blade* function and *handle* function).

6. Oversimplification: When *weight maintenance functions* is presented only as a subclass of *functions related to digestive system*, then this fails to do justice to the role in weight maintenance of other organ systems and of the general metabolic functions of the body.

7. Overemphasis on subsumption: ICF’s restriction to *is-a* relations means that other sorts of relations between functions and processes are neglected. Such simplifications are not unique to ICF but are present also within ontologies like the Gene Ontology,² though the latter is now undergoing a process of reform in this respect which should lead to improvements. [2]

4 CONCLUSION

Improvements can be gained if the ICF would draw in its treatment of the relations between functions and body parts on a reference ontology of anatomy such as the Foundational Model of Anatomy (FMA)³. It can then very easily incorporate a mereological axis in its treatment of processes, for instance by deriving from:

bronchopulmonary segment part-of *lung*
assertions to the effect that:
function of bronchopulmonary segment part-of *function of lung*
functioning of bronchopulmonary segment part-of *functioning of lung*

The full mereological treatment of functions and processes must however include also assertions such as:

biting function part-of *ingestion function*
chewing function part-of *ingestion function*
and similarly:

biting process part-of *ingestion process*
chewing process part-of *ingestion process*
which make room also for the part-whole relations between processes and subprocesses. Most importantly, however, an adequate ontology of processes and functions must draw a clear distinction between functions, functionings, and their different sorts of by-products.

REFERENCES

- [1] Smith B and Grenon P. (2004) *The Cornucopia of Formal-Ontological Relations*, *Dialectica*, 58:3 (2004), 279-296.
[2] Smith B, Ceusters W, Koehler J, Klagges B, Kumar A, Lomax J, Mungall C, Neuhaus F, Rector A, Rosse C. (2005) *Relations in Biomedical Ontologies Genome Biology*. 2005;6:R46.

² <http://www.geneontology.org/>

³ <http://sig.biostr.washington.edu/projects/fm/>