Philosophy of design research

Theo A. F. Kuipers

(University of Groningen, www.rug.nl/staff/t.a.f.kuipers, T.A.F.Kuipers@rug.nl)

EPSA-ESF-symposium New Challenges for Philosophy of Science

Athens, October 2011

"Not so very long ago most philosophers of science maintained that the subject-matter of this volume was uninteresting […] because technology was taken to be an applied science in which the application itself presented no new philosophical challenges."

> From Anthonie Meijers' editorial introduction to *Philosophy of Technology and Engineering Sciences*, Vol. 9 of the *Handbook of the Philosophy of Science*, Elsevier, 2009, p.1, 1453 pp.

The message of Meijers is very true, even in the much wider sense of disinterest in applied and design sciences in general. Sure, there have been exceptions, e.g. Von Wright (1963), Bunge (1966), and Simon (1969).

However, witness the volume referred to, containing 41 contributions, there is a growing interest in the last two decades, and rightly so.

[What is technological science? (Hansson, 2007)]

Six defining characteristics that distinguish technological from the other (natural) sciences.

(1) **human-made** rather than natural objects as their (ultimate) study objects,
(2) include the practice of engineering **design**,
(3) define their study objects in **functional terms**,
(4) evaluate these study objects with category-specified **value statements** (safety, health),
(5) employ **less far-reaching idealizations** than the natural sciences,
(6) no need of an exact mathematical solution when a sufficiently close approximation is available.

In combination, the six characteristics are sufficient to show that the technological sciences are neither branches nor applications of the natural sciences, but form a different group of sciences with specific characteristics of their own.

Design research in three levels

Focus of this talk: science-based design research or, simply, **design research**.

Speaking of '**design sciences**' is misleading because in modern science there is design research in almost all academic disciplines. Cf. talk of descriptive or explanatory sciences.

In the area of descriptive and explanatory (nomic) research the level distinction of (nomic) **laws, theories, and research programs** provides an illuminating viewpoint (Kuipers, 2007).

By analogy, three levels of design research can be distinguished:

1) technical norms (Von Wright (1963), Niiniluoto (1993) or technical rules (Banse and Grünwald, 2009), or, as I propose to call my version, **design laws**,

2) **design theories**, identified by the analogy,

3) **design research programs** (Kuipers et al., 1992, Kuipers, 2001, Ch.10).

Design laws

Niiniluoto (1993/1994): design research (kind of applied research) serves epistemic and practical utilities and focuses on the establishment of technical (or practical) norms. Strongest version:

"If you want *A*, and (you believe that) you are in a situation *B*, then you ought to do *X*".

He argues that practical norms have a truth value, which enables support by basic research. The norm is true iff the corresponding causal statement "X causes A in situation B" is true.

Proposal: introduce the (relative) distinction between (observational) **structural** and **functional properties** (events, processes, etc.), i.e., properties that may be directly imposed by humans versus properties that may indirectly be aimed at. [NB. = Intentional (non-biological) version of the distinction]
A **design law** is a true causal (observational) law (or regularity) of the form:

"Functional property A in situation B can be achieved by imposing structural property X"
or "Imposing structural property S in context C causes functional property F"

Hence, a design law is a special kind of (observational) causal law.

- speed bumps (S) cause the local (C) reduction of the speed of car traffic (F)
- Cf. heartbeats (S) cause the circulation of blood (F) in the body (C).

Design theories

To represent, usually very complex, cases of design research, e.g. drug design, speech technology, food technology, traffic technology, one needs compound representations.

The aim of (complex) design research can be adequately represented within a space of relevant properties by **property profiles** of (prototypes of) the products to be made and by two, mutually orthogonal, distinctions (Kuipers et al., 1992, Kuipers, 2001, Ch. 10):

- **structural and functional profiles**
- **desired and operational profiles**

On this basis, **design theories** can be formulated, tested, and improved:

An artifact with structural profile S causes functional profile F

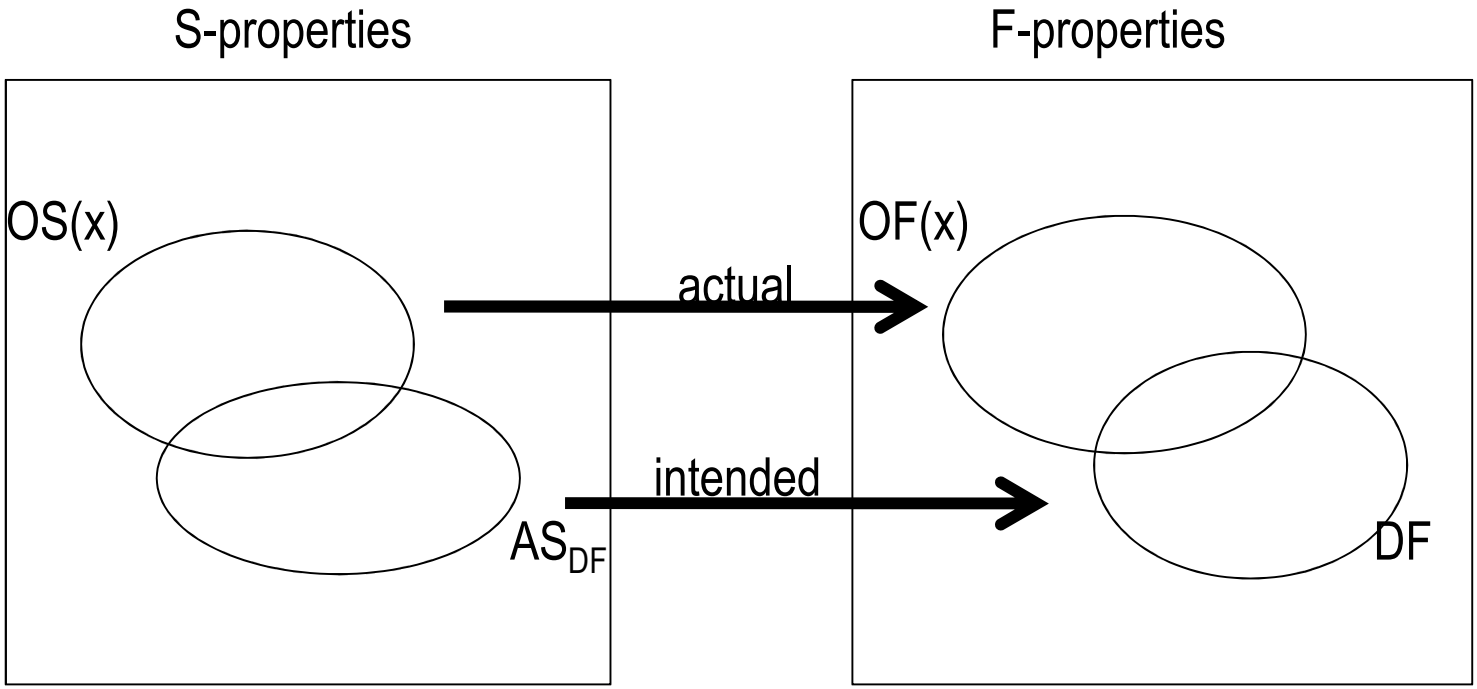
Two versions

Actual: Prototype x with operational structural profile OS causes (operational) functional profile OF

Intended: An artifact with structural profile S causes desired functional profile DF

A structural profile is **appropriate** for DF (AS_{DF}) if it causes the desired functional profile (DF).

Design theories, cont.



OS(x)/OF(x)	operational structural/functional profile of prototype x
AS_{DF}/DF	appropriate structural / desired functional profile
→	causal relation

Testing is done by making prototypes or by simulation. Two kinds of change:

- progress by having a new prototype realizing the functional characteristics better
- adapting the desired functional profile (Vos (1991): Drugs Looking for Diseases)

This brings us later to design research programs, see below.

Design theories, cont.

The causal claim of a design theory resembles the (realist) claim of a *proper* (nomic) theory, viz. that the theoretical entities and properties cause and explain such and such observational facts.

E.g. typical explanatory causal proper theories, e.g. theories of Newton, Darwin, utility theory.

Similarities (Kuipers, 2001, Ch. 9):

Design research aims at (theories about) products with certain desired functional features
Nomic research aims at theories about phenomena with certain (desired) observational features.

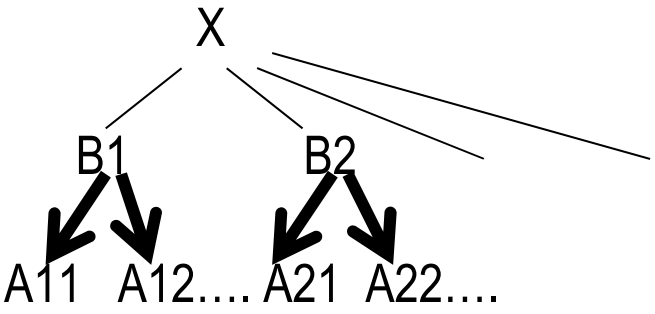
Differences:

1) theoretical entities and properties are <u>not observable</u>
   structural features are, like functional features, <u>observable</u>
2) observational features are derivable from the proper theory: <u>explanatory</u>
   functional profiles are (claimed to be) caused by structural profiles: <u>descriptive</u>

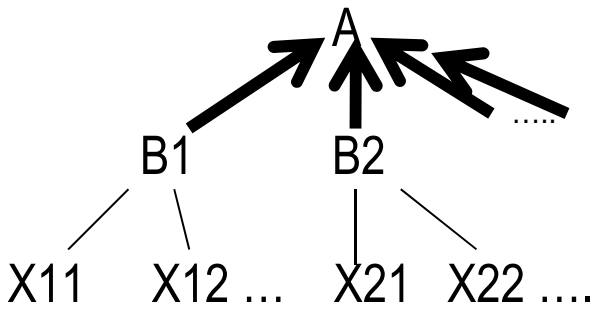
Hence, design theories are a kind of descriptive causal theories (cf. reaction equations)
If not transparent, they ask for explanation of the working of the products, e.g. aspirin.

Design theories, intermezzo

This is rather different from Niiniluoto's contrastive picture of theories in (Niiniluoto, 1994):



basic sciences



applied (i.e. predictive or design) sciences.

Left(basic): one causal factor X (e.g. gravity) is applied in a variety of situations B1, B2, … with the resulting effects A11, A12,…..
Hence, a collection of specific causal statements united by the same causal factor

Right(applied): various means X11, X12, … for obtaining in different situations B1, B2, … a given single goal A (in very general form e.g. health, peace).
Hence, a collection of design laws (IN:technical norms) united by the same (intended) effect

In my view, nomic and design theories are similar: complex entities ideally generating desired observational / functional features

Design research programs

Finally, the development of a design research program, assumed to be guided by some core idea, the so-called ‘lead’, can be described as a sequence of (or even a network of) changing profiles.

This enables to easily indicate similarities and differences with descriptive and explanatory (nomic) research, notably their respective kinds of progress. See next slide.

Moreover, the cooperation between a design program and one or more other research programs can be described as that between a guide program and one or more supply programs (Zandvoort, 1986).

On its turn, this can be seen as an explication of the main ideas of the Starnberger Gruppe in the 70s, e.g. about aerodynamics.

Design research programs, cont.

Similarities:

Progress in a design research program: the new prototype possesses more desired (functional) properties and fewer undesired ones than the old prototype.

≈ progress in a nomic research program (Kuipers, 2001, Ch. 9)

In both cases, in particular, progress by idealization and concretization

Functional equivalents

≈ observationally equivalent theories (on logical grounds)

Differences: apart from: observable vs non-observable and descriptive vs explanatory

1) a **design target set** (desired profile) is a free and changeable choice, whereas given a domain and a vocabulary, the **nomic target set** is fixed;

2) a design target set is **known**, whereas the nomic target set is not;

3) straightforward (comparative) evaluation of a (new) prototype, in contrast to indirect evaluation of a (new) theory, viz. by observational consequences and non-empirical properties;

4) to revise a prototype may be expensive for material reasons, to revise a theory is relatively inexpensive;

5) for a fixed domain and vocabulary, nomic truth approximation is, ideally speaking, free from external influences, whereas design research is basically open to such influences.

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