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The scientific qualifier

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Abstract

Reflections on what is considered 'scientific' (and what is not), and research as the general way to achieve it.

1 Introduction

The adjective 'scientific' — from *scientia* [L], 'knowledge, science, skill' — as well as its Greek equivalent, επιστημονικό, qualify any noun with an air of respect or 'prestige' (Perdicoúlis, 2012c), implying a body of trustworthy and specialised knowledge, so much in content as in procedure. The activity responsible for both the content and the procedure of science is known as 'research'.

2 Research

Research — from *re*-, expressing intensive force + *cerchier* [F], search (Oxford Dictionary of English, 2010) — refers to the study of materials and sources, including all knowledge obtained and registered in a trustworthy manner. Research is original work intended to acquire knowledge about the structure and function underlying observed facts (φαινόμενα [Gk]). With or without any particular application or use in view, research is designated respectively as *applied* or *basic* (OECD, 2002, p.30).

Research is often coupled to another original work, known as 'development', which draws on knowledge from research and/ or practical experience, and is directed to the production or improvement of materials and/ or services, as well as their application (OECD, 2002, p.30). This is a practical interface of research (or science, in general), putting knowledge to [good] use.

3 Specialised content

Specialists should be trusted more than generalists, perhaps, as they should know the object of their speciality particularly well. Medicine has advanced notably, for instance, since medical doctors started specialising. But as they gain focus or expertise in a narrow field of subjects, specialists may lose perspective or the 'wider picture' (Figure 1) — e.g. the patient as a person.

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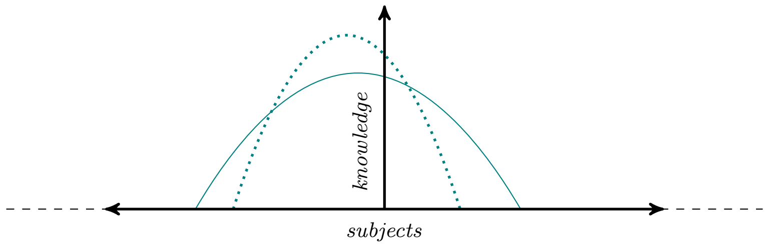

Figure 1 Some people specialise more (dotted line) and others less (solid line)

Specialisation can be taken to extremes, always relying on 'more specialists' to 'know better'. A notable case is that of scientists and the assessment of quality of academic publications, in which case they eventually turn to meta-information specialists: the indexing and ranking services (Perdicoúlis, 2013a). Super specialisation departs from the realm of reality into a meta-reality — from an object to its 'shadow' — that is capable of taking over as a new reality (Perdicoúlis, 2013c). Hence, deep specialisation may provoke an alienation from the context of reality.

People with 'broader' knowledge (Figure 1) are rare nowadays, but have been popular and appreciated in the past — for instance, in the classic antiquity (e.g. Socrates, Plato, Aristotle) and in the renaissance (e.g. Leonardo, Galileo). It should be true that the amount of knowledge in the 21st C. AD is much greater than in the antiquity or renaissance, and it could be argued that people do not have the time to absorb and retain so much information. So, they may try to excel through specialisation, at the cost of losing the 'big picture' from sight.

4 Procedure

Scientific also refers to the *way* that knowledge is obtained — that is, the method or procedure (Perdicoúlis, 2012b) — as well as the *way* this knowledge is registered and transmitted. Obtaining knowledge in a trustable way is safeguarded by the scientific protocol (Perdicoúlis and Glasson, 2006), presented as a concise process diagram (Perdicoúlis, 2011b) in Figure 2.

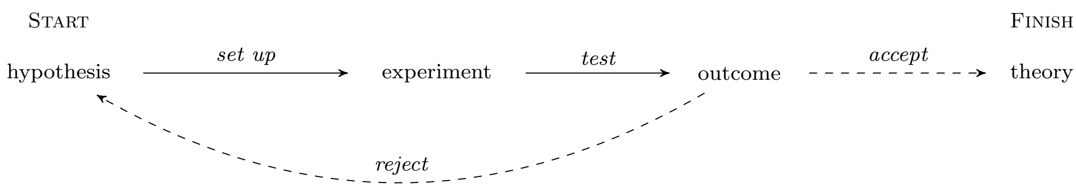

Figure 2 Synopsis of the scientific protocol

At the beginning and at the end of the scientific protocol (Figure 2) lies the same 'general rule': first as a *hypothesis*, and — after rigorous testing and approval — then as a *theory*. The formulation of this general rule (by induction) and its application or use (by deduction) involve meticulous transformations of information (Perdicoúlis, 2012d; Perdicoúlis and Glasson, 2006) — Figure 3.

Karl Popper, the founder of scientific testing and 'falsification' of hypotheses (Chalmers, 1999, pp.59–86), argues that no amount of empirical observation can ever conclusively verify a hypothesis

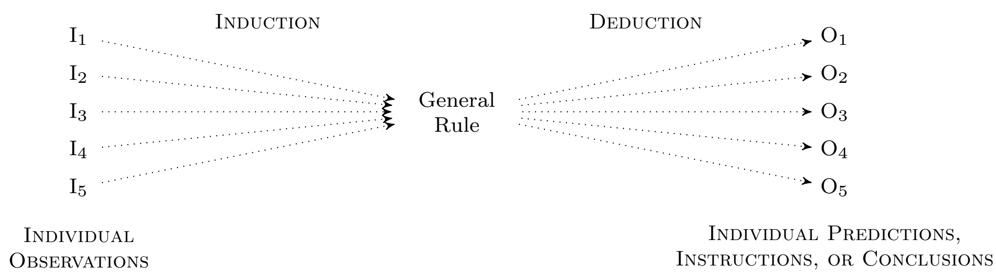

Figure 3 Induction and deduction in the formulation of a general rule to be used in the scientific protocol

(Perdicoúlis, 2012a), but a single observation can falsify it. Simply put, Popper — and subsequently the entirety of science since the second half of the 20th C. — denies verification in favour of falsification of hypotheses (Kuhn, 1996, p.146). Hence, science does not aim to accumulate evidence to support a certain hypothesis, but rather to disprove it.

Falsification of hypotheses gives importance to rigorous and ruthless testing, and meticulous procedural protocols to accompany these tests. Laboratories are elevated to high status as the testing grounds for many of the natural sciences. As a consequence, the conception or creation of hypotheses passes to an obscure background; hypotheses are 'freely created by the human intellect' (Chalmers, 1999, p.60), with all the confidence that scientific testing will trustfully refute the 'wrong' ones.

After securing trustworthy knowledge through the scientific protocol, this knowledge needs to be registered and transmitted appropriately. This feat — at least in principle — entails a large, worldwide system of research centres, databases, publications, and teaching institutions. At least the communicative part, which is the scientific writing (Perdicoúlis, 2012e), is expected to exhibit some quality standards (Perdicoúlis, 2013d) such as: (a) *traceability*, so that trustworthiness of content can be traced back to the sources, (b) *objectivity*, even when handling value judgements, (c) *precision*, or coherence of facts and arguments, and (d) *accuracy*, or being 'to the point' (Perdicoúlis, 2012e).

5 Challenges

In this context, the first challenge is to *specialise and also keep the 'big picture' in view.* This may mean the renaissance man (and this time, also the woman) is back. This is a great personal investment for many, as well as for institutions — both research and teaching.

Another challenge is *scientific communication* — mainly writing, which is the more permanent kind, as it constitutes records to be used as sources. The intent is to preserve what has been discovered and known, as 'scientifically' as possible. As many people are involved in writing, and thus transmitting information about knowledge, everyone of these authors must be aware of the responsibility to write 'scientifically' (Perdicoúlis, 2012e) — but are they taught this at school or at the university? Are the teachers prepared for this?

Without a doubt, *the way of obtaining trustworthy knowledge* is cornerstone. The current scientific method, based on hypothesis testing and falsification, has made much progress worldwide, but has far-reaching implications for science and humanity, with challenges of their own.

A major implication is that we tend to ignore or disregard age-old human knowledge (Perdicoúlis, 2013b), as if it had no value at all. The challenge is *how to make use of personal and collective human knowledge into science*. How can the two parts meet?

Another implication is that the creative part of the human intellect, responsible for the formulation of hypotheses (*inductive* thinking) becomes under-developed due to lack of attention and/ or its inferior status (Perdicoúlis, 2012d). Since scientific testing is a selection process, and selection is 'as good as the best option available' (Perdicoúlis, 2011a, p.142), it makes sense to direct every effort towards creating better hypotheses. Thus, the second challenge is *how to complement or combine the deductive thinking of falsification and its intensive/ exhaustive testing with the creative inductive thinking that produces hypotheses*. Possible models may be sought in established — although not 'scientific' — practices, such as *inter alia* engineering, architecture, the fine arts, and even detective work (Perdicoúlis, 2012d).

Regarding the scientific method itself, a number of fragilities have found their way to current practice and deserve particular attention. One of the crucial challenges for producing 'good science' (or not) is *peer review*, which — for many reasons built into the academic and publication systems — is performed in a limited sampling mode: typically 'one-off, two-peer' reviews. The seal 'peer reviewed' gives the false impression of 'global, unquestionable, and irrevocable approval', and this is likely to discourage any further criticism from other peers. A second overarching challenge is the *appropriateness of method*, which raises questions in sensitive subjects such as ethics (e.g. human dignity, animal rights), measurement and assessment (e.g. direct, complex, by proxy), as well as validity (e.g. applicability, replicability). Although not easy to resolve, these challenges must be at least present in the conscience of scientists, as well as of the wider community.

Finally, a look at the impostors. Popular culture, such as that created by the social media and the entertainment business, often employs special appearances to convey the confidence of 'scientific' — for instance, the addition of a grid, simulating graph paper, may give a sense of laboratory-grade to products such as toothpaste; measurements, indices, and unusual words elevate the degree of difficulty (and, apparently, specialisation) of information, and this remoteness with an air of erudition or scholarship makes practically anything look 'scientific'. *Caveat emptor*.

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