

Theories – Initial Notes

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1. The Word ‘Theory’

We want to talk about theories in science. But what is a theory? According to the *American Heritage Dictionary (AHD)*, the word ‘theory’ comes from the Latin word ‘*the¹ria*’, which comes from Greek word ‘*the¹ros*’ [spectator], which probably comes from ‘*thea*’ [a viewing] + ‘*oros*’ [seeing]. Notice, in this connection that, the word ‘theater’ also derives from ‘*thea*’.

Also notice the etymological¹ similarities between ‘spectator’ and ‘speculate’. Thus, one of the meanings of ‘theorize’ is “to speculate”, so that a theory is a speculation. This is the *weak sense* of the word ‘theory’. It is the usage intended when someone says, for example, “I have a theory why so-and-so happened.” The weak sense of ‘theory’ is mostly synonymous with ‘conjecture’. And scientists and philosophers often theorize in this way.² However, this is not the important sense of the word ‘theory’.

The *weak sense* of the word ‘theory’ must be contrasted with the *strong sense* of the word ‘theory’, which is more germane to discussions of philosophy and science. The strong sense is described in *The Skeptic’s Dictionary (SD)* as follows.

a theory is a principle or set of principles for explaining, organizing, unifying, and/or making sense out of some range of phenomena.

A considerably more ambitious account is offered by *AHD* as follows.

- 1a. Systematically organized knowledge applicable in a relatively wide variety of circumstances, especially a system of assumptions, accepted principles, and rules of procedure devised to analyze, predict, or otherwise explain the nature or behavior of a specified set of phenomena.

¹ Etymology is a branch of linguistics. Etymologists, many of whom work for companies who write dictionaries, formulate theories about the origins and evolution of words. To give “the derivation” – or “the etymology” – of a word is to give an account of its history and development. These accounts are often summarized in dictionaries.

² This is also the usage probably intended when someone disparages a claim, or even a body of knowledge, as “just a theory”. This is usually a failure to understand the precise meaning of ‘theory’ in science and philosophy.

A number of words in the above definitions bear scrutiny – ‘knowledge’, ‘explain’, ‘phenomena’.

2. Knowledge

AHD probably employs a very loose definition of ‘knowledge’, but if we are careful about this word, we see that there is a potential philosophical problem with their account of theories. Let us consider a very brief analysis of the word ‘knowledge’, which is the noun associated with the verb ‘know’. The verb ‘know’ is used in at least three ways, which are illustrated in the following table.

objectual³ knowledge (acquaintance)	Jay knows Kay
procedural knowledge	Jay knows how to tie his shoes
propositional knowledge	Jay knows that his shoes are untied

The sort of knowledge we are primarily concerned with is propositional knowledge. Consider the following sentence.

Jay knows that his shoes are untied

What can we logically deduce from this statement? It seems that at least the following two statements can be deduced.⁴

Jay **believes** that his shoes are untied

it is true that Jay’s shoes are untied

This is summarized in the following principles about knowledge.

- (1) knowledge entails belief
- (2) knowledge entails truth

The issue of what else is involved in knowledge is a big issue in philosophy. (See Appendix)

In any case, knowledge entails truth. We do not want knowledge to be an inherent part of our definition of ‘theory’, because we do not want truth to be an inherent part of our definition. The reason is that not all theories are true. When we discover that a theory is not true, we don’t say it is not a theory, we just say that it is not a *satisfactory* theory.

³ The word ‘objectual’ is a neologism (invented word) meant to refer to *knowledge of objects* in contrast to *knowledge of propositions*. The standard adjectival form of ‘object’ is ‘objective’, but ‘objective knowledge’ does not mean ‘knowledge of objects’, so it is unavailable.

⁴ One might wish to propose a third logical consequence.

(3) Jay knows that he knows that his shoes are untied,
which would then entail

(4) Jay knows that he knows that he knows that his shoes are untied,
and so on *ad infinitum*!

3. Explanation

The notion of explanation is another heavy-duty philosophical notion. As with most words in natural language, the word ‘explain’ has many meanings, very subtly related to one another. For example, according to one definition, ‘to explain’ means “to *offer* an explanation”. For example, suppose you ask me:

why is the sky blue?

And suppose I reply:

because the sky is made of blue cheese.

I have indeed *offered* an explanation, although needless to say, it is probably the stupidest explanation you have ever heard. The definition can be logically clarified as follows.

iff⁵ person *p* **explains** [why *S*]
 p offers an explanation [for why *S*]

 iff person *p* **offers** an explanation [for proposition *P*₁]
 person *p* **offers** a proposition *P*₂ [as an explanation for *P*₁]⁶

Now, the obvious further question is, under what circumstances is an offered explanation a satisfactory explanation, or any sort of explanation at all. By analogy, I might *offer* you a bowl of peas *as* a dessert, but it does not follow that a bowl of peas is a satisfactory dessert, or that is any sort of dessert at all.

In brief, when we say that theories *explain* phenomena, we should understand this as saying that theories are *offered* as explanation of phenomena, that they are *intended* to explain phenomena, not that they in fact *succeed* as explanations.

This brings us to the logic of explanation. Under what circumstances does one proposition *P*₁ explain another proposition *P*₂? Suppose you ask me:

why is the sky always yellow?

I can legitimately answer as follows.

the sky isn’t always yellow!

Of course, the proposition that the sky is not always yellow does not explain why the sky is always yellow. Perhaps I should reply as follows.

nothing explains why the sky is always yellow, because *in point of fact* the sky isn’t always yellow.

The following principle summarizes this idea.

⁵ The expression ‘iff’ is short for ‘if and only if’.

⁶ Technically, *P*₂ is called the *explanans*, and *P*₁ is called the *explanandum*.

Only a fact (i.e., true proposition) can be explained;
a false proposition cannot be explained.

Accordingly, all sentences of the following form are false.

the sky is always yellow because \mathcal{S}

An analogous question concerns whether any sentence of the following form is true.

\mathcal{S} because the sky is always yellow

And the answer is, once again “no”. This is summarized in the following principle.

Only facts (i.e., true propositions) can *properly* serve as explanations.

The above considerations can be summarized in the following *partial* truth-table.

P	Q	P because Q
F	F	F
F	T	F
T	F	F
T	T	???

Notice in the last case that the truth value of ‘ P because Q ’ is left undetermined. This is because ‘because’ is not a truth-functional connective. Merely knowing that both P and Q are true in no way informs us concerning the truth-value of ‘ P -because- Q ’.

4. Phenomena

The next issue in clarifying both the *SD* definition and the *AHD* concerns the word ‘phenomena’, which is a multi-faceted word. First, ‘phenomena’ is a Latin-derived word with a Latin-derived inflection⁷. Specifically, the singular form is ‘phenomenon’, whereas ‘phenomena’ is the plural form – one phenome**non**, two or more phenome**na**.⁸

Notice that, unlike some authors, *SD* and *AHD* do not insist that the phenomena to be explained are “natural”. This amendment would be unfortunate, since it would restrict theories to the so-called “natural” sciences. We do not wish to pre-judge what sorts of domains can be theorized about. Accordingly, we wish to take phenomena in the widest sense possible, including publicly observable

⁷ The inflection of a word pertains to its various forms – as in ⟨‘I’ ‘me’ ‘my’ ‘mine’⟩ and ⟨‘he’ ‘him’ ‘his’⟩ and ⟨‘she’, ‘her’, ‘hers’⟩.

⁸ Other singular-plural pairs based on Latin are: ‘medium’, ‘media’, ‘datum’, ‘data’.

events (as in physics and biology), and intuitions (as in mathematics, ethics, and linguistics).⁹ In particular, we experience some phenomena with our external senses (sight, smell, etc.), but we experience other phenomena with our internal senses. Whereas the external senses are fairly easy to comprehend even by young children, the internal senses are a little trickier, and require self-reflection (a key to philosophy!) For example, we are often aware of our thoughts, sometimes in the form of spoken words, sometimes in the form of pictures or other graphical items. But we are not aware of them via the usual external senses, but rather via our internal senses. In this connection, the often-used metaphor is "the mind's eye", although we also have a "mind's ear" as well.¹⁰

5. Our Initial Definition of 'Theory'

We will propose the following definition of 'theory', which is a slight adjustment to the *SD* definition.

A theory is a collection of principles **intended to** explain, organize, unify, and/or make sense out of some specified range of phenomena.

The beautiful thing about this view is that, according to what it says, it is *itself* a theory. It is a collection of principles (just one to be exact) intended to explain a rather abstract range of "phenomena" – namely, what a theory is. It is a theory of theories. It seems plausible that any theory \mathcal{T} of theories should correctly predict that \mathcal{T} itself is in fact a theory.

Having defined what a theory is, we must quickly add that we have not defined what a *good* theory is. Of course, some theories are better than others, and some theories are just plain terrible. There are a number of ways that a theory can be evaluated, which we will discuss in greater detail as we proceed.

6. Euclid and *The Elements*

Euclid flourished around 300 BC in Alexandria, Egypt during the time of Ptolemy I.¹¹ Geometry was a well-established art in ancient Egypt, as amply witnessed by the Pyramids (2600-2400 BC). It was also practiced in Babylonia. However, beginning with Thales of Miletus (630 BC), the Greeks made significant progress in geometry, and science in general, by introducing the notion of *formal proof*.

The notion of formal proof, particularly as employed in geometry, moreover became a very important component of Greek "liberal" education, so much so that it is reputed that Plato's Academy¹²

⁹ The distinction between internal and external observation sometimes gets blurred in the psycho-sciences, including psychology, psycho-linguistics, and psycho-physics. Often, a subject is asked report *internal* observations – e.g., do these two colors look the same to you? – to the experimenter. The problem is that the experimenter cannot report truly that the two colors do look the same to the subject, but only that the subject *reports* that they look the same. It is strictly speaking hearsay!

¹⁰ The mind's eye should not be confused with the mind's "I".

¹¹ Ptolemy Soter was the first of the Greek pharaohs of Egypt, having been the chief lieutenant of Alexander the Great (356-323 BC), after whom Alexandria was named. Upon Alexander's death, Ptolemy and two other generals – Seleucus and Antigonos – divided up the vast Alexandrian empire. Ptolemy created the first "museum" – to honor the muses. His most famous descendant was Cleopatra, more specifically Cleopatra VII – the last pharaoh of Egypt. Cleopatra had affairs with Julius Caesar and later Mark Antony. After the defeat of Antony and Cleopatra at the battle of Aktion (31 BC), and their famous suicides, Egypt was annexed by the Roman Empire, thus ending the Ptolemaic (also called Ptolemaic) Dynasty.

¹² The word 'academy' comes ultimately from 'Academus', the name of a Greek hero, after whom a grove near Athens is named. In 387 BC, Plato set up a school in this grove, and called it 'Academeia' (ακαδημεια), after the grove. We translate continued...

had the following inscribed over its gate “Let no one enter here who does not know geometry”. Over the next few hundred years, many individual theorems were proved, by many individuals, but the culmination of Classical Greek mathematics came with Euclid’s *Elements*. In this great work, one of the greatest scientific works of all time,¹³ Euclid shows how all the concepts and laws of geometry can be *logically reduced* to just 23 definitions, 5 common notions, and 5 postulates. The importance of this work to western civilization is hard to over-estimate; for example, it has been claimed that, short of the Christian Bible, Euclid’s *Elements* is the most widely circulated book in history!

7. The Euclidian Paradigm

Euclid’s *Elements* provides a paradigm¹⁴ for what a theory should be. This paradigm may be described as follows.

- (1) a *given* realm of phenomena (the **data**)
- (2) a set of **laws**/generalizations distilled from (1)
- (3) a *proposed theory* to explain, systematize, organize, and/or codify (2), which includes:
 - (a) a proposed set of primitive concepts
 - (b) a proposed set of primitive postulates (axioms)
 - (c) a proposed set of common notions (logical and notational machinery)
 - (d) a proposed set of definitions
 - (e) a demonstration of how (a)-(d) codifies (2)

In the next chapter, we will examine a very simple example of a theory in the Euclidean paradigm.

this as ‘the Academy’. This school lasted until A.D. 526, when it was officially closed by Emperor Justinian (Eastern Roman Empire), because it taught “pagan” ideas. In the humble opinion of this author, we can date this event as the official beginning of the “Dark Ages”.

¹³ The other work that is in the same league is Sir Isaac Newton’s *Philosophiae Naturalis Principia Mathematica*, commonly known as the *Principia*.

¹⁴ The word ‘paradigm’ is a big word in philosophy of science, especially since its prominent use by Thomas Kuhn in *Structure of Scientific Revolutions*. The usage here is fairly close to the original meaning; a paradigm is an exemplary instance or model.