Some notes on the Aristotelian origin of the distinction between a falsificationist's and verificationist's view of science: together with corrections to my earlier account.

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Abstract: It has not always been realized that Karl Popper's analytic distinction between the logically stronger falsificationist's view of science and the logically weaker verificationist's and inductivist's view of science is a modification of Aristotle's distinction between the notions 'all' and 'some'. This document traces this distinction anew in a way that corrects my earlier (Corkett, 1997) account in which a semantic rather than a logical view was taken of this distinction. For example: when writing the 1997 paper I was not aware that the universal law 'All swans are white' represented a universal categorical proposition 'All S is P' where 'S' represented the subject 'swan' and the 'P' represented the predicate 'white'. In this document I try to cover some of the main points of my 1997 paper in a way that clarifies their origin in the Law of Tripartite Entailment, a logical rule unknown to me fifteen years ago.

Keywords: Aristotle; the Law of Tripartite Entailment; Karl Popper's non-inductive theory of method; falsificationist's view of science; verificationist's view of science; fisheries management

1. Introduction

Fifteen years ago I started a program of research in which Karl Popper's non-inductive theory of method was to be applied to the management of the world's commercial fisheries. In my first publication I suggested we might associate a fisheries stock assessment with a verificationist's view of science (Corkett, 1997). I still regard this suggestion as a valuable one but it was flawed by errors and excessive verbosity in my 1997 publication. For example: when writing the 1997 paper I was not aware that the universal law 'All swans are white' represented a universal categorical proposition 'All S is

P' where 'S' represented the subject 'swan' and the 'P' represented the predicate 'white'. In this revised account I explain anew how the logically stronger falsificationist's view of science and the logically weaker verificationist's view of science originate as a distinction between the notions 'all' and 'some'; a demarcation that forms part of the Law of Tripartite Entailment, a logical rule unknown to me fifteen years ago.

2. What is a sound argument?

Let us take as our paradigm for a sound argument the following relationships of consequence from Mates (1972, p. 6):

All Senators are old (premise); (1a)

All octogenarians are Senators (premise);

Therefore, all octogenarians are old (conclusion), and

Some Senators are old (premise); (1b)

Some generals are Senators (premise);

Therefore, some generals are old (conclusion)

Argument (1a) is sound; that is it meets the Law of the Transfer of Truth since every conceivable circumstance that would make the premises true would also make the conclusion true. The Law of the Transfer of Truth guarantees only that *if* the premises were true, then the conclusion is also true: the law does not guarantee that any of the premises are in fact true, nor does it give us any information about the truth-value of the conclusion in case one or more of the premises is false (Mates, 1972, p. 7). Argument (1b) is unsound. It does not meet the Law of the Transfer of Truth, not every conceivable circumstance that would make the premises true would also make the conclusion true. The logical form of arguments (1a) and (1b) are derived from Aristotle's distinction between a **universal categorical proposition** 'All swans are white' and a **particular categorical proposition**

'Some swans are white' where black and white swans are proxies for the subject (S) (as swans) and predicate (P) (as black and white) of Aristotle's propositions (Table 1).

Table 1. Aristotle's distinction between universal and particular categorical propositions

Universal proposition	'All S is P'	'All swans (S) are white (P)'
Particular proposition	'Some S is P'	'Some swans (S) are white (P)'

3. The presence and absence of existential import

There is an important difference between particular and universal categorical propositions with respect to what is referred to as their **existential import**. The 'some' in the particular categorical proposition 'Some S is P' implicitly assumes that at least one of the subject items designated by the 'S' term actually exists if the proposition is 'true'. That is 'Some S is P' (Some Swans are white) which amounts to 'At least one S is P' (At least one swan is white) can only be 'true' if S's (swans) actually exist (Rescher, 1964, p. 115). From this it follows if 'Some swans are white' is 'true' it can be verified by finding a white swan. By contrast the term 'all' as in the universal categorical proposition 'All S are P' (All swans are white) means 'all that there are' as in 'all swans that there are, are white.' (Rescher, 1964, p. 115).There is no assumption that S's (swans) exist so that the possible 'truth' of 'All swans are white' does not depend on the actual existence of any swans. Since the possibility that there exist no swans remains open it follows that 'All swans are white' cannot be verified by finding a white swan nor can we draw inferences from observing white swans to 'All swans are white'. No matter how many instances of white swans may have been observed, this does not justify the conclusion that *all* swans are white (Popper, 1959, p. 27).

4. Falsification and the Law of the Retransfer of Falsity

A **falsification** is a falsifying inference that involves an entailment (Rescher, 1964, p. 133); that is: 'All S is P' (All swans are white) entails its obverse form 'No S is non-P' (Black swans do not exist)(Table 2). This transfer of truth from a universal categorical proposition to its obverse can be given, as:

If 'All swans are white' (All S is P) is accepted, then (2)
'Black swans do not exist' (No S is non-P) must be
accepted as true

Inference (2) guarantees only that *if* 'All swans are white' were true, then 'Black swans do not exist' is also true. It does not guarantee that 'Black swans do not exist' is in fact true; indeed it gives us no information about the truth-value of 'Black swans do not exist.'

Table 2. Aristotle's distinction between a universal proposition and its obverse form

Universal proposition	'All S is P'	'All swans (S) are white (P)'
Obverse form of a universal proposition	'No S is non-P'	'No swans (S) are non- white(P)' or 'Black swans do not exist'

We can reformulate inference (2) in terms of the transfer of falsity, as:

If 'Black swans do not exist' is accepted as false, (3)
then the Universal Law 'All swans are white' must
be regarded as false

We are not concerned here with whether a universal categorical proposition and its obverse form are in fact false. All that is required for the valid transfer of falsity is: *if* the obverse form of the law were false, then the law itself is also false. If we take 'Here is a black swan' as representing the empirical evidence in the form of a test proposition (Corkett, 2009), then we can illustrate an empirical falsification by the following immediate inferences:

If 'Here is a black swan' is accepted as true then 'Black swans do not exist' must be rejected as false (4a)

If 'Black swans do not exist' is rejected as false then 'All swans are white' must be rejected as false (4b)

Inferences (4a) and (4b) combine to form a falsification that upholds the Law of the Retransmission of Falsity. This deductive law retransfers falsity without any conceivable exception; that is: every situation that makes the test proposition 'Here is a black swan' true also makes 'All swans are white' false. Of course we may have made a mistake in accepting the test proposition as true; however in no way whatever does this mistake diminish the validity of a falsification (Corkett, 2009).

5. The Law of Tripartite Entailment

The Aristotelian distinction between the notions 'all' and 'some' (Table 1) makes no provision for singular propositions, like 'Socrates is white' (Mates, 1972, p. 207). However, singular propositions do form part of more a general analytic rule that I will refer to as the Law of Tripartite Entailment. This three parts law starts from a universal categorical proposition pertaining to all things of a certain kind. It provides that in these circumstances:

(i) Where all things have the property *P*, as: ‘All swans are white’ we can derive, for any individual thing *a* belonging to this kind,

(ii) That the thing *a* has the property *P*. From (ii), in turn, we can derive

(iii) That there exists a thing that has the property *P*, as: ‘At least one white swan exists’, a strictly existential proposition with the logical form of a ‘there-is’ statement (Popper, 1959, p. 68).

Under this tripartite rule a universal categorical proposition (i) entails singular proposition (ii) and a strictly existential proposition (iii); and singular proposition (ii) entails a strictly existential proposition (iii). But (iii) does not entail either (i) or (ii), and (ii) does not entail (i). In other words (i) is logically stronger than (ii) and (iii) and (ii) is logically stronger than (iii) (Popper, 1983, p. 184).

The asymmetrical logical strength of the Law of Tripartite Entailment is illustrated by the soundness of argument (1a), a relationship of consequence with the logical form of an ‘all’ notion as ‘All things have the property *P*’ and the unsoundness of argument (1b), a relationship of consequence with the logical form of a ‘some’ notion or ‘At least one swan is white’ (see section 3) as ‘There exists a thing that has property *P*’.

6. Testing universal laws by corroboration

The universal categorical proposition ‘All S is P’ or ‘All swans are white’ has no existential import; that is: it does not assert the existence of S’s or swans (see section 3). It has the logical form of a ‘there-is-not’ statement (Popper, 1959, p. 69) and it asserts ‘No S is non-P’ or ‘Black swans do not exist’ (Table 2). That is: a universal law asserts non-existence (which is why it is falsifiable) but it does not assert existence (which is why it cannot be verified). Consider the universal laws ‘All swans are white’ and ‘All swans are black’. They only assert non-existence, as:

(i) ‘All swans are white’ excludes the existence of black swans, red swans and pink swans.

(ii) ‘All swans are black’ excludes the existence of white swans, red swans and pink swans.

These universal laws can only form a test of each other if they contradict each other and in order for this to occur they have to assert existence; that is: they have to meet the existential assumption that swans exist (see section 3). If this assumption is represented by the singular proposition ‘there exists at least one swan’ then the entailment of this proposition by both universal laws would mean they contradict each other since a failure to realise a falsification would corroborate just one of the laws, as:

(i) If ‘All swans are white’ entails ‘there exists at least one swan’ then it asserts the existence of a white swan and excludes the existence of black swans, red swans and pink swans. The failure to realise a falsification by finding a black swan corroborates ‘All swans are white’ or

(ii) If ‘All swans are black’ entails ‘at least one swan exists’ then it asserts the existence of a black swan and excludes the existence of white swans, red swans, and pink swans. The failure to realise a falsification by finding a white swan corroborates ‘All swans are black.’

Which of the two laws would be corroborated by a failure to realise a falsification can only be determined after conducting a thorough search for a white or black swan, always bearing in mind the unsuccessful attempt to find a red or pink swan cannot constitute a test since this failure would corroborate both ‘All swans are white’ and ‘All swans are black’ (Popper, 1959, p. 374).

6.1. Corroboration vs induction

For those used to thinking inductively Popper’s insistence that ‘All swans are white’ be corroborated by a failure to realise a falsification (i.e. by failing to find a black swan) rather than confirming 'All swans are white' (by finding a white swan) is much ado about nothing. You simply declare that an inference may be drawn from white swans to 'All swans are white' and the problem of induction disappears! As Martin Gardner (2001) states: 'Popper's critics insist that 'corroboration' is a form of induction, and Popper has simply sneaked induction in through a back door by giving it a new name'. If Gardner is right and the distinction between 'induction' and 'corroboration' is merely one of semantics then Popper's non-inductive theory of method is certainly in trouble. However Popper's non-inductive theory of method is not based on the meaning of certain words. It is based on the existential distinction of an Aristotelian logic; a distinction or demarcation that follows from the well-known fact that a universal categorical proposition (universal law) has no existential import (see section 3). No matter how many instances of white swans are observed, this does not justify the conclusion *all* swans are white – a form of inference known as induction (Popper, 1959, p. 27).

7. Distinguishing (demarcating) between a falsificationist's view of science and a verificationist's view of science

Karl Popper (1983, p. 184) uses the asymmetrical logical strength of the Law of the Tripartite Entailment to provide a heuristic or methodological distinction between:

(a) The logically stronger critical or falsificationist attitude in which a theory or policy is required to be bold; that is an explanatory theory or management policy is required to assert so much that it may easily turn out to be false. Under this **falsificationist's view of science** the scientist tries to find fault with his theories and policies. That is: he tries to select them by the removal of faulty ones a process referred to as corroboration. This selection by corroboration is encapsulated in Popper's trial and error epistemological schema: $P_1 \rightarrow TT \rightarrow EE \rightarrow P_2$. Starting from some problem P_1, a tentative theory TT is proposed, which is subjected to error-elimination EE in the form of a critical feedback that gives rise to new problems P_2 and the process is then repeated.

(b) The logically weaker inductive or verificationist attitude in which ideally a theory is expected to be true; that is a theory should be constructed of true propositions. Since we do not know all of these, it must at least consist of those propositions which have been verified or ‘confirmed’ or ‘induced’ or perhaps shown to be ‘probable’. Thus verified strictly existential hypotheses should for this reason belong to science. That is: they belong to a **verificationist’s view of science**.

This distinction between the logically stronger view of science ((a) above) that excludes a verificationist’s view of science and the logically weaker view of science ((b) above) that excludes a falsificationist’s view of science is matched in the Law of the Tripartite Entailment by the *ability* of the universal categorical proposition (All things have the property *P*) to entail the logically weaker strictly existential proposition (There exists a thing that has the property *P*) and the *inability* of the weaker strictly existential proposition to entail the logically stronger universal categorical proposition.

8. Applying the Law of the Tripartite Entailment

The Law of Tripartite Entailment is used by Popper in the construction of a schematic relationship of consequence that entails a scientific prediction. That is a sound scientific prediction is given by a tripartite schema in which the prediction or conclusion (Pr) is a deductive consequence of two premises: a universal law (U) and the initial conditions (I) (Table 3A). Under Karl Popper’s non-inductive theory of method inferences are never drawn from facts or data in the form of singular propositions to the prediction of future events as represented by the monism of Table 3B. Rather, a scientific prediction is based upon observational experience in the form of ‘initial conditions’ (I in Table 3A) entailed by some universal theories (U in Table 3A). The entailment of the ‘initial conditions’ and the prediction by these universal theories is essential in arguing from the past to the future. But these universal theories are not in turn inferred from facts or data. They are independently tested conjectures (Popper, 1978).

Table 3. Schematic relationship of consequence: A, Deductive dualism for scientific prediction; B, Inductive monism.

	A	Dualism	B	Monism
Universal premise	U	Universal Law		NA
Singular premise	I	Initial conditions	I	Data (observations)
Conclusion	Pr	Prediction of singular event	Pr	Prediction

8.1. Problem solving: engineering

All life is problem solving (Popper, 1999) and the problems of a deductive science are solved in fundamentally the same way as our day to day problems are solved by common sense, the method of trial and error. That is we work by trying out solutions to our problems and discarding the false ones as erroneous. This selection by elimination can be described by the following epistemological schema (see section 7(a)):

$$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2 \qquad (5)$$

We start from some problem P_1, proceed to a tentative solution in the form of a tentative theory TT, which may be partly or wholly mistaken; in any case it will be subjected to error-elimination EE in the form of a critical feedback that may consists of experimental tests, new problems P_2 arise from our critical discussion and testing and the processes is then repeated (Popper, 1979a). This problem solving method is the one used by the engineer all the time and can be represented by a modification of Table 3 in which an engineering trial and error replaces the initial conditions (Table 4A). From a logical point of view the engineer has to realise the technical version of the initial conditions by trial and error so that the universal laws are able to entail both the initial conditions (I in Table 4A) and the engineering specifications (S in Table 4A).

Table 4. Schematic relationship of consequence: A, Engineering (from Popper (1979b); B, Fisheries management (from Corkett, 1997).

	A, Engineering version	B, Management version
Universal premise	U Universal law	U Rules of thumb
Singular premise	I Trial and Error	I Trial and Error
Conclusion	S Engineering specifications	N Normative goals (norms)

8.2. Problem solving: fisheries management

Corkett (1997) modified Popper's (1979b) schema for engineering (given in Table 4A) to accommodate the trial and error of a fisheries management as a social engineering (Table 4B).). Particularly important is the fact that in this tripartite schema, normative laws in the form of goals, objectives and standards (N in Table 4B) form part of the problem situation needing solution (P_1, P_2 … in schema (5)). Consider the task of managing a fishery. What are given are the goals (norms) to be attained (such as the requirement for a sustainable fishery) together with some theories (U in Table 4B). What remains to be found by the fishery manager are the initial conditions (I in Table 4B) that have to be realised by trial and error in such a way that the goals are entailed by the theories and initial conditions. Ulltang (1998) suggests that in a fisheries science the emphasis is on predictions but the kinds of possible predictions and their properties will be determined by the extent to which we are able to formulate universal laws and their initial conditions. However in the case of an applied fisheries science universal laws (theories) are replaced with rules of thumb, universal rules that guide the a posteriori trial and error of the fisheries manager by explaining what cannot be achieved and should not therefore be attempted (Corkett, 2011).

9. Discussion

Under Karl Popper's falsificationist's view of science a proposition (theory, conjecture) is given empirical status if and only if it can be falsified or tested. Karl Popper (1959, p. 48) does not demand that every empirical scientific proposition (theory) must have in fact been tested, he only demands that every such proposition (theory) must be capable of being tested. That is: at least one possible falsification (see section 4) or potential falsifier must exist that describes a logically possible event that conflicts with the theory in question. It is important not to demand that the potential falsifier or possible falsification be true. To make this discussion less abstract I will give four examples: two of falsifiable propositions, and two of propositions that cannot be falsified.

(1) The theory ‘All swans are white’ is falsifiable since it contradicts the following possible test statement that describes a logically possible observable event (which is incidentally, false): ‘On Canada Day, 2012 at 3.30 p.m. a black swan landed on the band stand of the Halifax Public Gardens. ’ Corkett (2009) gives a similar example in which a black swan represents a test statement that falsifies ‘All swans are white’ in its obverse form ‘Black swans do not exist’.

(2) The equiproportional rule for copepod development is falsifiable. The rule assumes that each development stage of a copepod occupies the same proportional amount of time relative to other stages at any constant temperature (Corkett et al., 1986). The equiproportional rule was experimentally falsified by Tande (1988). Of course it is to be understood that this falsification simply creates a new problem situation (P_1, P_2… in schema (5)) containing new problems for creative minds to solve.

(3) Purely existential propositions are not falsifiable as in Popper’s (1983, p. xx) example: ‘There is a ceremony whose exact performance forces the devil to appear’. While such a proposition cannot be falsified it is in principle, verifiable: it is logically possible to find a ceremony whose performance leads to the appearance of a human-like form with horns and hooves. If a repeated carrying out of this ceremony fails to achieve the same result, it would not be a

falsification, for perhaps an unnoticed yet essential aspect of the correct ceremony was omitted.

(4) Verified existential hypotheses are not falsifiable. Corkett (2002) gives the following example: 'There exists a maximum sustainable yield (MSY) of 30 million pounds for stock X'. Why this verified (data-fitted) hypothesis cannot be falsified can be illustrated in a simple way. Say, for the sake of argument, the further collection of data suggests a new MSY of 40 million pounds for stock X, then this new value could not refute or falsity the old value of 30 million pounds, for it remains logically possible (or we can always hope) that a further collection of data would return the MSY to the original value of 30 million pounds.

Falsifiable in the sense of falsification (see section 4) has nothing to do with the question whether or not certain possible experimental results would be accepted as actual falsifications. It is a matter of elementary logic that the ability of an inference to validly retransfer falsity (i.e. a falsification) does not mean that the inference itself is in fact false (see section 4). An excellent example of an experimental falsification is provided by the physiologist Alan Hodgkin when in 1939 at the age of 25 he succeeded in pushing a fine saline-filled electrode inside a squid nerve fiber and made 'the astonishing discovery that, during the nerve impulse, the potential of the interior of the axon changed transiently from being about 50 mV negative with respect to the sea water in which the nerve had been placed, to being about 50 mV positive when it was expected to go to 0 mV' (Denton, 1999). Experiments involving experimental falsifications or refutations such as Hodgkin's experiment on the conduct of nervous impulses change the problem situation (P_1, P_2… in schema (5)) and in so doing present new and different problems requiring solution by the method of trial and error. The idea that somehow a falsification can be translated into an experimental result in which the theory in question is shown to be in fact false is referred to as a falsificationism. Misinterpreting a falsificationist's view of science as a falsificationism is widespread, it is implied by Corkett (2009) and is found throughout the research program of the ecologist Tony Underwood (Underwood, 1997). An example of falsificationism more relevant to the fisheries is provided by Hilborn and Mangel (1997)'s focus on likelihood and Bayesian methods in which non-falsifiable mathematical models are confronted with data.

The Bayesian methods of Hilborn and Mangel (1997) also provide a good example of a verificationsit's view of science. For example a version of Bayesian analysis is said to involve a search for truth where 'we might have other information that allows us to judge a priori which model is more likely to be true' (Hilborn and Mangel, 1997, p. 8). However this a priori search for truth cannot involve the testing of theories and models since a critical testing can only take place after decisions have been taken; that is a testing is conducted a posteriori (see situational logic of schema (5)). Quite apart from this inability to conduct critical tests the logically weaker Bayesian viewpoint can only have a small number of identified models or theories from which to judge truth. This is to be compared with the logically strong process of selection by corroboration (see section 6) in which erroneous solutions to the solving of problems are removed from an infinite class or set of potential solutions by error elimination (EE in schema (5)). Compared to a falsifiable and corroborative view of testing (involving a falsificationist's view of science) a falsificationism and a verificationist's view of science share a similar logical weakness; neither approach possesses a methodology capable of selecting or identifying theories from an infinite class or set.

While verified existential propositions (hypotheses) belong to a verificationist's view of science (see example (4) above), isolated existential propositions (hypotheses) that are not entailed by a universal law are an example of 'metaphysics' (see example (3) above). Such propositions do not belong to a falsificationist's view of science (since they cannot be falsified), do not belong to a verificationist's view of science (since they have not been verified), and are not an example of mathematics (a non-falsifiable discipline). Corkett (1997, p. 166) gives an example of 'metaphysics' in the form of an isolated existential statement, as:

> An isolated existential statement … is the very paradigm of a metaphysical assertion (pink swans exist). Metaphysical assertions can be verified by the finding of a 'pink swan' …

An isolated existential proposition (given as 'There exists a thing that has the property *P*' in The Law of Tripartite Entailment) can be referred to as being 'metaphysical' in the sense that it is logically weak and cannot be falsified. However my 1997 paper was incorrect in stating that an isolated existential proposition can be verified by a pink swan. Isolated existential propositions (hypotheses) that are not entailed by universal laws take the logical form of 'At least one swan is white' which is a variation on the notion 'some' as in 'Some swans are white' (Table 1). We can say the isolated existential hypothesis 'At least one swan is white' (given as 'There exists a thing that has the property *P'* in the Law of the tripartite Entailment) can be verified by a white swan (not a pink swan). Pink swans are associated with universal laws (not existential hypotheses). That is pink swans join red swans in forming potential falsifications or potential falsifiers of 'All swans are white' and 'All swans are black' (see section 6).

As Berkes et al., (2001) point out Corkett (1997, p. 166) has characterised the models of stock assessment as being of 'no more value in the management of the world's fisheries than the primitive magic spells of witch doctors'. While this is certainly a poor formulation of 'metaphysics' (a correct formulation is given in example (3) above) the response from Berkes et al., (2001, p. 225)

> But let us not get carried away. If used properly, with due regard to limitations of data and the inherent uncertainties in ecosystem processes, conventional fishery management science possesses many strengths and has a great deal of experience behind it.

Illustrates just the kind of inductive view of fisheries management that my research program is designed to combat. Instead of understanding that all management decisions have to be taken, we are now led to believe decisions and values (norms) can be reduced to facts. However under Popper's deductive theory of method decisions together with objectives and goals (such as sustainability) and standards (such as the precautionary principle) cannot be produced from, or be reduced to facts. Goals, objectives and standards reflect the values of the proponents and form part of the problem situation requiring solutions (P_1, P_2… in schema (5)). Effective solutions to the problems of any fishery require the *corroboration* of bold imaginative policies (see section 6) not the *inductive* collection of facts (data) that are certain.

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