DISCUSSION

A Theory-Laden Observation
Can Test The Theory

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I. INTRODUCTION

In a recent paper Franklin et al. [1989] considered the familiar thesis that observations are theory-dependent and that this dependence prevents the observational testing of scientific theories. Franklin and his collaborators provide several examples of cases in which theory-dependent observations do provide such tests, and they close by challenging those who deny that such tests are possible to 'present a workable example from actual science' (p. 231). I will present such an example in this note, but I will do so in the course of defending an important thesis that is implicit in the paper cited above: the relation between observation and theory must be determined on a case-by-case basis, rather than by resting content with a general philosophic argument. When we look at specific cases we do find situations in which a particular test is blocked by theory-dependence, but we also find cases in which this does not occur. Moreover, in the one example that I will examine in this note, the two possibilities interact in a, perhaps, surprising way.

II. SUPERLUMINAL VELOCITIES

Since 1971 radio astronomers studying quasars have been discovering cases of apparent superluminal velocities. (See Zensus and Pearson [1987], for a review of the situation as of late 1986.) All of these cases involve pairs of objects (I will call them A and B) that are moving away from each other; we can take A to be fixed and consider the velocity of B relative to A. The objects involved are quasars, or parts of quasars, that have been detected by radio telescopes using very-long-baseline interferometry. These quasars are sufficiently far away that the motion of the earth around the sun can be ignored. Observations of A and B made at different times show an increase in distance
between them. This increased distance indicates a change in their angular separation as viewed from the earth. If B's distance from the earth can be determined, the increase in the angular distance between A and B can be determined and, using the known time between the observations, B's transverse velocity can be calculated. Since the objects in question are quasars, they exhibit a redshift that can be used to determine their distance from the earth.

It is clear that the determination of B's distance from the earth involves the use of a substantial number of theoretical claims—for example, in recognizing that the object's spectrum shows a redshift, in interpreting this redshift as due to a recession velocity and in using the Hubble constant to determine the distance. However, I will consider only one aspect of this background for present purposes. The recession velocity (and thus the distance from the earth) is calculated using the formula for the Doppler effect. Now Newtonian physics and special relativity yield different formulas for this effect. Since it is currently believed that relativity is correct, the calculation is naturally done using the relativistic formula:

\[ \beta = \frac{(S^2 - 1)}{(S^2 + 1)}, \]

where \( \beta \) is the recession velocity, taking the velocity of light in vacuo as one, and \( S \) is the ratio of the observed wavelength of the spectral line in the quasar to the wavelength of that line on earth. Clearly, \( \beta \) can never be equal to or greater than one. Here, then, is an example of a specific observation that, due to theory-dependence, cannot be used to test a particular theory. We have no means of determining the recession velocity of a quasar other than by its Doppler shift. But the relativistic formula for determining the recession velocity from the shift in wavelength can never yield a result that contradicts relativity. This is not surprising, given that this formula was deduced from special relativity.

According to the Newtonian formula,

\[ \beta = S - 1. \]

This formula can yield a superluminal recession velocity. We have here the makings of a genuinely troubling form of theory-dependence. If a live debate between relativity and Newtonian mechanics were currently in progress, we would have a situation in which proponents of each theory interpret the data using the resources of their favoured theory, and each gets a result in conformity with that theory. In addition, the Newtonian would get a result that contradicts relativity, although the reverse will not occur since Newtonian theory places no restrictions at all on possible velocities.¹

¹ In Popperian terms, velocity magnitude provides a dimension along which relativity theory has higher empirical content than does Newtonian theory. Recognizing this point indicates that there is an additional level of complexity that would have to be taken into account if we were actually comparing the two theories.
It would, however, be a serious error to end the discussion at this point. Even though no relativistically interpreted redshift can ever yield a recession velocity that contradicts relativity, the recession velocity can play a role in a somewhat more complex observation that can contradict relativity: **there is no limit on the possible transverse velocities that may result once the radial distance has been determined.** As has already been noted, there are a number of cases in which an apparent superluminal transverse velocity results. There is some disagreement over the exact number of apparent superluminal velocities that have been discovered because the detailed calculation includes two constants—the Hubble constant and the deceleration parameter—whose values are uncertain. We need not pursue the details of these calculations for present purposes (see Porcas [1986], pp. 13–17). We can note, however, that using values for these constants that minimize the number of cases of apparent superluminal velocity yields at least eighteen instances as of 1986. These include values in excess of nine times the velocity of light (see Porcas [1986], pp. 17–20; Blandford [1986], p. 311).

3 THE DUHME—QUINE THESIS

While the case we are considering yields apparent superluminal velocities, it would be premature to conclude that relativity has now been refuted. The current consensus among scientists working in this field is that these are only apparent cases of superluminal velocities, and that they can be accounted for within the framework of relativity. According to the most widely accepted account, these are all cases in which B is moving almost directly towards the earth at a high velocity; the transverse motion detected from the earth is only a small transverse component of this motion. As a result, when astronomers make two observations of A and B n years apart, they cannot assume that n is the time required for the increased separation that they have detected. The light from B that is detected by the second observation will have left B long after the light from A that is detected by the second observation. In other words, the increased transverse distance between A and B may well result from hundreds of years of motion even though only a few years intervened between the two observations.

It will immediately be recognized that this defense of relativity is an example of the Duhem—Quine thesis in action. A recalcitrant observation need not provide a logically compelling reason for rejecting a theory. Several hypotheses will typically be involved in interpreting an observation and we can often

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2 It is, of course, sufficient that a superluminal velocity could be observed for the test to be legitimate.

3 The actual calculation requires considerations from general relativity, but the slide from special to general relativity is not important in the present context since superluminal velocities are incompatible with both theories.
save a preferred theory by giving up some auxiliary hypothesis. This is a familiar and an important point, but I have cited it here in order to emphasize that it is not a point about the theory-dependence of observation. The Duhem-Quine thesis follows from an elementary point of logic: the derivation of a false conclusion proves that at least one of the premises is false, but does not pinpoint the error when more than one premise has been used. This is a pervasive feature of intellectual life that has nothing in particular to do with observation. For example, the problem also arises when we deduce an inconsistency from a set of propositions. Two familiar examples that do not involve observation will reinforce this point. First, when Einstein developed special relativity, the two major axioms of this theory were generally considered to be mutually inconsistent. Einstein's rejection of simultaneity at a distance amounted to the recognition that the contradiction required three premises and that the third premise—that two events must be either simultaneous or not simultaneous—was to be rejected. Second, the debate over the Einstein–Podolsky–Rosen experiment concerns which member (or members) of a set of mutually inconsistent propositions should be rejected.

Moreover, the fact that there are cases in which scientists make use of this flexibility to save a theory will throw some light on another sense in which observation is sometimes said to be theory-dependent. It is sometimes claimed that scientists fail to notice data that contradict their preferred theories. For example, this seems to be Kuhn's point when he discusses the anomalous card experiment ([1970], pp. 112–13). No doubt this occurs sometimes, but it is certainly not a universal feature of science. If it were, the theory-preservation manoeuvres permitted by the Duhem–Quine thesis would never be required since there would be no apparent contradictions of the preferred theory. Kuhn's own arguments for the thesis that anomalies need not be taken as counter-instances is sufficient to show that scientists regularly notice results that are prima facie incompatible with the current paradigm.

4 CONCLUSION

I have been concerned here with a case in which a single theory is being compared with observational results rather than a case in which two competing theories are being compared. We have seen that the theory-dependence of an observation can block a particular observational test. But this occurs because of specific features of the example—not because of a pervasive feature of the logic or epistemology of science. We have also seen that an observation that cannot itself test a specific claim of a theory can still play a role in a more complex procedure that can test that very claim.

There are two philosophical morals to be drawn at this point, both of which support the position of Franklin and his collaborators. First, the familiar claim that an observation that depends in an essential way on a theory cannot
provide an objective test of that very theory is false. Second, and more important, we should be wary about accepting general philosophical claims about scientific procedures. As our example illustrates, sometimes an observation will depend on a theory in a way that makes it impossible for that observation to test that theory. But this will not always occur, and the actual situation can only be decided by examining specific cases.

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REFERENCES


