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What factors are involved in the resolution of scientific disputes? What factors make the resolution of such disputes rational? The traditional view confers an important role on observation statements that are shared by proponents of competing theories. Rival theories make incompatible (sometimes contradictory) observational predictions about a particular situation, and the prediction made by one theory is borne out while the prediction made by the other theory is not. No sophisticated traditionalist thinks this is the entire story about rational theory resolution. We need to take into account a number of maneuvers (legitimate and illegitimate) open to the defender of the (apparently) disconfirmed theory. Also, there may be standards besides predictive accuracy involved in theory-choice, such as simplicity, coherence with other well-confirmed theories, etc.[1] But the existence of a base of observation statements that can be shared by proponents of competing theories is an essential ingredient in the traditional account of rational theory resolution.

Paul Feyerabend, Thomas Kuhn, and Paul Churchland have called into question this account of theory-resolution. According to these philosophers, substantially different and competing scientific theories are *semantically incommensurable*. Roughly, a pair of theories is semantically incommensurable when proponents of such theories inevitably talk past one another, at least partially, when attempting to resolve their disagreements. As a result, any traditional account of rational (or actual) theory-resolution (any account that involves an observation language sharable by proponents of substantially different competing theories) must be mistaken.

Consider two charges that have been levelled against the semantic incommensurability thesis (SIT). The first is that SIT ignores two facts: (a) there is a semantic feature of observation terms such that it can be

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expressed by the proponents of competing theories, and (b) in certain circumstances, those expressions can count in favor of one of the theories and against the other. The second charge is that SIT is self-defeating. My contention in this paper will be that SIT falls prey to these charges, but not for the reasons usually given.

1. THE SEMANTIC INCOMMENSURABILITY THESIS

In order to understand SIT, the best place to begin would be with the semantic theory that is supposed to underwrite it. But defenders of SIT have not been forthcoming in this regard. In absence of such a theory, the best way to grasp the thesis is by seeing how it works in the case of a particular example. In the late 17th century, Newton argued that light consists of particles that travel in straight lines. Huygens and Hooke opposed him by arguing that light is composed of waves propagated through ether. Over 100 years later, early in the 19th century, an experiment (now sometimes known as the Fresnel experiment) demonstrated that light was capable of wave-like behaviors. In particular, when light is shone at a small circular obstacle, its shadow can exhibit a bright spot of light at its center. This experiment (along with Young's experiment) has been identified as the major force leading to the reign of the wave theory of light for about a century.[2]

Defenders of the semantic incommensurability thesis would analyze the Fresnel episode, which is often thought to be an ideal example of rational theory resolution, as follows. Proponents of the wave and particle theories of light mean and refer to different things by the term 'light'. As a result, the apparently contradictory claims made by proponents of the wave and particle theories ('There will [will not] be a spot of light in the middle of the shadow') are not contradictory. They are no more contradictory than 'The bank [financial institution] is entirely red' and 'The bank [riverside] is not entirely red'. On this analysis, it does not necessarily follow that there is nothing to choose between these theories. After all, some proponents of the particle theory may have considered this experiment a devastating setback — and perhaps rightly so given their evidence. The point is that the choice between the theories was not dictated (even in part) by any sort of agreement between the parties about the facts; to put it another way, what makes any experiment a setback for one theory and a victory for the other has nothing to do with their making incompatible predictions about the world, because such predictions are never made.

2. THE SEMANTIC FOOTHOLD RESPONSE

The most detailed attempts to spell out the nature of the semantic foothold that exists for a pair of competing theories usually specify the *referential* properties of expressions (Scheffler 1967, Field 1973, Putnam 1973, Kitcher 1978, Devitt 1979, 1981, and Fodor 1984, 1987). So according to the referential foothold charge, we can grant that the concepts expressed by 'mass' in Newtonian and relativistic mechanics are different, or that the concepts expressed by 'planet' in the heliocentric and geocentric theories are different, or that the concepts expressed by 'light' in the wave and particle theories are different. However, the objects, states, properties, or events to which such terms refer are the same. This characterization of the referential foothold response ignores important subtleties in the various semantic views alluded to above. For our purposes, all these responses (although different in important ways) try to overcome SIT by specifying some sort of referential foothold that is sufficient to serve the epistemological purposes of the traditionalist.

The accounts of reference underlying the referential foothold response undermine SIT because they snip the connection between a term's intention and its extension (Kripke's 1972 is the *locus classicus* on this position). In other words, proponents of the referential foothold response have tried to show in some detail how the referential properties of an expression are independent (or at least largely independent) of different individuals' theoretical commitments. If we assume that the reference of an expression (like 'light') is not determined by the theoretical commitments of the person who uses it, then the semantic incommensurability thesis will be undermined. Applying such a theory of reference to our examples, Newton and Hooke could still refer to the same stuff with tokens of the term 'light' even though they believed very different theories of light.

Although I am sympathetic to accounts of reference that are (to at least some degree) theory-invariant, little sympathy can be expected from defenders of the semantic incommensurability thesis. Kuhn insists upon an account of meaning that is not "construed in purely referential terms . . . [M]y arguments have at least implied that something from the realm of meanings, intensionalities, concepts must be invoked as well" (1982, p. 679). Feyerabend and Churchland go further by proposing that the semantic identities of observation expressions (including, one supposes, their referential properties) are fixed *solely* in terms of the theories in which they are embedded.

> [A]s I formulated it in my first English paper on the topic: the interpretation of an observation language is determined by the theories which we use to explain what we observe and it changes as soon as these theories change (Paul Feyerabend, 1975, p. 228–9).
>
> [The term 'white'] acquires a semantic identity as, *and only as*, it comes to figure in a network of beliefs and a correlative pattern of inferences (Paul Churchland, 1979, p. 14, emphasis added).

Given this disagreement about the nature of reference, the debate surrounding the referential foothold strategy is likely to remain deadlocked, with each side insisting upon the superiority of their own semantic theories and intuitions.

Adding to the debate another account of reference or a defense of an account already offered will not break the deadlock. So let's explore a different semantic foothold response, one that does not involve denying that the meaning (i.e., the intension and the extension) of a term is a function solely of the theory in which it is embedded. I will propose a response to SIT that grants its central semantic contention. Besides being more subtle and possessing greater rhetorical force, I think this rejoinder will afford deeper insight into the central failings of SIT.

2.1. *The sin of semantic incommensurability: Insensitivity*

Even if we grant that the semantic identity of an expression is fixed entirely by the role it plays within a theory (or belief-system), only a semantic theory unduly insensitive to context will support SIT. I will defend this claim in three stages. 2.1.1 offers a thoroughly intuitive defense of the insensitivity charge. 2.1.2 gives the same argument in terms of a well-developed account of how to define terms that could serve the purposes of SIT. In 2.1.3, I respond to potential objections.

2.1.1. *The intuitive argument.* What conditions must a semantic theory satisfy in order to support SIT? Consider again the Fresnel experiment. Are the predictions made by the wave and particle theories contradictory? In order to answer this question, we should distinguish two different ways in which statements might be contradictory (Scheffler, 1967; English 1978).

(a) Pa and −Qb are *intensionally contradictory* iff P and Q have the same meaning and a and b have the same meaning.

(b) Pa and -Qb are *extensionally contradictory* iff P and Q have the same extensions and a and b have the same referents.

The proponent of semantic incommensurability needs an account of the meaning of terms that makes it impossible for Hooke and Newton to make intensionally or extensionally contradictory predictions about the behavior of light. It must imply that the term 'light' used in making wave theory predictions *can never have the same meaning* and *can never have the same extension* as the term 'light' used in particle theory predictions.[3] Otherwise (assuming the other terms used in their predictions are also synonymous or coextensional) they could contradict one another.

Let us begin by granting that the semantic identity of the term 'light' (both its intension and extension) for proponents of the wave and particle theories is fixed by the role the term plays their theories. On this assumption, we should grant that proponents of the wave and particle theories often "talked past" one another; that is, on some occasions they employed tokens of the term 'light' that were not synonymous and not coreferential. But the defenders of SIT need more than this. They must show that Newton and Hooke were *conceptually straight-jacketed* when it came to making predictions about the behavior of light: Newton *always* expressed a particle concept of light and referred to something made out of particles, and Hooke *always* expressed a wave concept of light and referred to something made out of waves. They could never express (and share) a concept of light that was agnostic about its structure.

The insensitivity objection should be clear: in order for the semantic incommensurability thesis to be true, our ability to express novel concepts must be considerably more restricted than it is plausible to suppose. To see just how bizarre a context-insensitive theory that supports SIT would be, suppose I assert "There's light in this room." You might ask, "What do you mean by 'light'? Do you mean a Newtonian sense of 'light' in which it consists of particles travelling in straight lines, or a Huygensian sense of 'light' in which light consists of waves propagated through an ether, or a modern sense of 'light' in which light is a type of electromagnetic radiation and consists of very strange photons?" According to the context-insensitive theory of meaning required for SIT, I would have to have meant one of these (assuming I know no other theories of light). But I could respond that I meant none of these, and this answer is intelligible and probably accurate. I am expressing a concept of light that is agnostic about some of its properties — its structure — and not about others.

Other examples of this sort are easily found. By using the term 'earth' we can express a concept that is agnostic about whether it orbits the sun; there is a sense of 'gene' in which genes are the hereditary material passed from generation to generation and which is silent about whether genes are made of DNA; there is a concept expressible by 'heat' which makes no assumptions about whether heat is molecular motion or a liquid-like caloric; and so on. And if proponents of competing theories employ terms expressing such concepts, it seems perfectly possible for them to contradict one another, both intensionally and extensionally, when making predictions on the basis of their theories.

The conclusion of the insensitivity charge is that SIT is false because *any* theory of meaning that could support it would have to be radically insensitive to the extraordinary variety of concepts that can be expressed by a term on different occasions of use. I think this intuitive argument defeats the semantic incommensurability thesis. However, I want to make the case again assuming a detailed account of how to define expressions such as 'light'. (As far as I know, it is the only well-developed account that will support SIT.) Of course, defenders of SIT may reject the following incarnation of the insensitivity objection because of the account of expressions I employ. Nonetheless, the intuitive argument still stands, especially in absence of a detailed semantic theory that is supposed to support SIT. It will also be helpful to go beyond the intuitive argument and see how SIT and the insensitivity objection are worked out at a more detailed level.

2.1.2. *Spelling out the insensitivity charge.* In order to make this intuitive argument clearer, we need an account of the meaning and reference of terms that is reasonably plausible, reasonably clear, and that will serve the purposes of the defender of semantic incommensurability. The description theory of terms and predicates is the only account I know that satisfies these conditions. It defines an expression F in theory T as follows (Russell, 1919; Ramsey, 1931; Lewis, 1970).

1. Conjoin the sentences in T that contain F.

Light consists of waves & light is bright & light is capable of casting shadows & light is emitted by the sun . . .

2. Quantify existentially (first or second order) over F.

There is an x such that x consists of waves & x is bright & x is capable of casting shadows & x is emitted by the sun . . .

3. Replace the existential quantifier with a definite description operator and define as F what satisfies the entire definite description.

Light is defined as the unique x such that x consists of waves & x is bright & x is capable of casting shadows & x is emitted by the sun . . .

This is not meant to be a *semantic* theory, since it only tells us how to define an expression in terms of other meaningful expressions; it does not give an account of the meaningfulness of expressions. This is a serious gap in this account of terms. For now, I intend to rely overtly on widely-held semantic intuitions about the terms occurring in the above definiens.

Following the insights of Wittgenstein (1953) and Searle (1958), we can distinguish two kinds of concepts expressible by the term defined above. The *complete definition* of F is fixed by conjoining all the sentences in T that contain F. When a token of F is defined in this way, we will say that it expresses its *complete concept.* If we conjoined all the sentences of the wave theory (or perhaps all the sentences Hooke would have accepted about light) in constructing the definition of 'light,' then it would express the complete wave concept of light. An *incomplete definition* of F is fixed by conjoining a proper subset of all the sentences in T that contain F. When F is defined in this way, we will say that F expresses its *incomplete concept.* For example, an incomplete definition of 'light' might not include the conjunct 'x consists of waves'.

Light is defined as the unique x such that x is bright & x is capable of casting shadows & x is emitted by the sun . . .

Prima facie it seems that proponents of the wave and particle theories of light could both express this incomplete concept. It does not contain in its definition any description of light that would be unacceptable to either Newton or Hooke.

Given the description theory, we can define a theory-neutral statement as follows.

(N) Statement S is neutral between competing theories T1 and T2 just in case the descriptive terms in S express concepts that make no assumption incompatible with either T1 or T2.

So the statement 'There is a spot of light in the middle of the shadow' will be neutral between the wave and particle theories of light if and only if the descriptive terms (e.g., 'spot', 'light', 'shadow') make no assumptions about the underlying constitution of light.

Now consider a pair of description theories. A *context-insensitive* description theory is one in which every token of a term can express only its complete concept. A *context-sensitive* description theory is one in which tokens of a term can express either their complete or incomplete concepts, depending on the context in which they are used.[4] According to the context-sensitive theory, in some contexts Newton's term 'light' might have expressed its complete concept, while in other contexts it might have expressed one of its incomplete concepts, such as the concept that is silent about whether light consists of particles. Adopting the context-sensitive theory obviously undermines the semantic incommensurability thesis. It shows that sometimes it is possible for proponents of competing theories to employ tokens of observational terms that are synonymous.

Furthermore, the context-sensitive theory of meaning can serve the traditionalist's epistemological purposes. Suppose the wave and particle theories predict tokens of statements that express complete concepts. So although they appear to be contradictions at a purely syntactic level (one predicts 'There will be a spot of light in the middle of the shadow' and the other predicts 'There will not be a spot of light in the middle of the shadow'), these predictions are not in fact (intensionally or extensionally) contradictory. However, they do imply tokens of neutral observational statements that are contradictory. In particular, they imply contradictory statements that express identical incomplete concepts of light. Therefore, there is a sharable, *intensional* semantic foothold that can count in favor of one theory and against one of its significantly different competitors.

2.1.3. *Some objections.* I want to consider three potential objections that a fictitious proponent of semantic incommensurability might level against the insensitivity charge. The first runs as follows: "Your description theory of terms is a cheat. Why should we assume that the terms appearing in the definiens of the wave and particle theorist's incomplete definitions are synonymous? On my view, the meaning of these terms are also fixed by the role they play in their respective theories. Since these other theories are likely to be different, it is, if not impossible, then at least extremely unlikely that proponents of competing theories will express identical incomplete concepts with tokens of their terms."

This argument takes advantage of the fact that there is no well-developed semantic theory that supports the semantic incommensurability thesis. So it will be no easy job to explain why the terms in the definiens of the definitions of the term 'light' for Newton and Hooke are synonymous. As a result, my response must ultimately rely upon two very firm semantic intuitions. The first is that mild disagreement about the nature of (say) shadows does not make it impossible for different people to express the same concept or refer to the same thing by tokens of the expression 'shadow'. The second intuition that tends to mitigate the force of the semantic incommensurability theorist's response concerns our ample expressive potential. For any expression we might use in the definiens of 'light', there are lots of concepts that Newton and Hooke could both express with that term (indeed, it is hard to think of an example of a concept that Newton could have expressed by the term 'shadow' or 'brightness' or 'sun' that Hooke was incapable of expressing). Further, some of these concepts are neutral between the wave and particle theories of light. In absence of very compelling reasons to think we are as conceptually straight-jacketed as the proponent of SIT requires, we should reject his objection.

Here is a second objection against the insensitivity charge that might be levelled by a defender of SIT: "I admit that the insensitivity charge shows that in typical situations, Newton and Hooke are capable of expressing identical concepts of light, concepts that don't make any assumptions about its underlying nature. However, this is irrelevant to the epistemological issue. The competing theories of light we have been considering employ very minimal concepts. The wave and particle theories employ a concept of light consisting of one description that is necessary and sufficient for its application. In the case of the wave theory, that description is *the unique x such that x consists of waves propagated through an ether*. When proponents of the rival theories are in the lab making predictions based on their incompatible scientific theories, *there is no sharable incomplete concept of light because the concepts employed by Newton and Huygens don't share any descriptions*."

We can elude this objection by noting that if proponents of these theories are to make predictions about a particular instance of the Fresnel experiment, they must refer to the particular light being shined at the obstacle and not some light that might interfere with the experiment or some irrelevant beam of light in some far corner of the universe. Any term that expresses the minimal wave or particle concept must refer to all and only those things that satisfy their associated description. So if the only concepts they can express when making predictions about the Fresnel experiment are the minimal concepts used by their theories, it is impossible for them to refer uniquely to that beam of light being shined at the obstacle.

So how can the wave or particle theory make any predictions about particular experiments? By specifying auxiliary hypotheses and initial conditions. By doing so, they add descriptions to the complete concept of light being employed in the derivation of the prediction: descriptions about the potential sources of light, the ability of light to cast shadows, its ability to interfere with the shadows created by other light sources, etc. The vital point is this: *The complete concept expressed by 'light' required by either theory in order to make laboratory predictions* *contains many more descriptions than the minimal concept expressed by either theory alone.* This gives us a foothold on which we can construct an incomplete concept sharable by both theorists.

The third objection is that I have not properly understood Kuhn's incommensurability thesis: "According to Kuhn, 'The claim that two theories are incommensurable is the claim that there is no language, neutral or otherwise, into which both theories, conceived as sets of sentences, can be translated without residue or loss' (1982, p. 670—1). Although the insensitivity charge undermines *some* version of the semantic incommensurability thesis, it doesn't show that Kuhn's incommensurability thesis is false."

Indeed it doesn't. The reason is that without some account of meaning, of what it is that is supposed to be preserved "without residue or loss", it is hard to tell whether the thesis is true or not. If we assume the description theory is on the right track, then Kuhn's incommensurability thesis is trivially true. We'll never find a language that satisfies the following two conditions: (a) it contains a term that expresses the complete wave concept of light (and no term that can express any other concept of light) and (b) it contains a term that expresses the complete particle concept of light (and no term that can express any other concept of light). But nothing of any epistemological import follows from the fact that no language can satisfy these incompatible requirements.

3. HOW SIT IS SELF-DEFEATING

Hilary Putnam has argued that SIT is self-defeating because it implies that it is impossible for us to understand (or communicate with) proponents of very different theories; yet, defenders of SIT are very adept at understanding (and communicating with) proponents of very different theories (1984, p. 113—119). Proponents of SIT respond (rightly I think) that SIT does not imply that it is *impossible* for proponents of very different rival theories to understand or communicate with one another (Kuhn, 1982; Feyerabend, 1987; Churchland, 1988). It only implies that communication across the theoretical divide is (in some sense) inevitably partial.

Although Putnam's argument does not succeed, I do think that SIT is self-defeating. In order to see why, let's ask the question: What makes the semantic incommensurability thesis so compelling? Its intuitive force derives from the fact that any time we adopt a new theory, our expressive capacity increases. For example, after we learn the theory of relativity, we can employ our old terms (like 'time' and 'mass' and 'velocity') to express brand new concepts. And it follows that this conceptual plasticity can, in many cases, lead to misunderstanding or partial understanding between proponents of competing theories. But, as we have seen, it doesn't have to. To go this far is to claim that SIT is false, not that it is self-defeating. Why should we think that it is self-defeating?

We can begin to see why SIT is self-defeating by noting that in order to undermine the traditional view of theory resolution, one would have to argue *against* conceptual plasticity. Only if our conceptual resources are radically circumscribed by the theories we believe will it be impossible for proponents of competing theories to share a common observational language. Conceptual plasticity actually strengthens the traditional view. The fact that our expressive potential is so plastic *dramatically improves* the prospects for theory-resolution on the basis of shared observation statements. The more concepts proponents of competing theories can express, the higher the probability that there will be concepts they can share that can adjudicate between those theories. For example, we could find an epistemically useful language that Newton and Hooke could share precisely because they were capable of expressing many different concepts with their uses of the term 'light'.

So to the extent that defenders of the semantic incommensurability thesis have been relying on the conceptual plasticity intuition, they have been arguing for the wrong conclusion. The semantic incommensurability thesis is self-defeating not because it makes it impossible for us to understand those whom we obviously understand (*pace* Putnam). It is self-defeating because the intuition that is supposed to nurture the semantic incommensurability thesis actually poisons it.[5]

NOTES

[1] Hempel's account of confirmation (1966) is an excellent example of the sophisticated traditionalist view.

[2] Kuhn explicitly states that this episode signalled a scientific revolution (1970, p. 12). Given Kuhn's view, we should expect that these paradigms of physical optics were semantically incommensurable. I realize that my account of this episode is simplified to the point of caricature. However, I think it makes little difference for the arguments I consider in this paper. For a more accurate portrayal of this episode, see Worrall (1989).

[3] Throughout this paper, I am sometimes ambiguous about just how radical the incommensurability thesis is supposed to be. A strong version of the thesis would imply that it is *impossible* for proponents of competing theories to express the same concept or refer to the same things when making predictions on the basis of their theories. A weaker version of the thesis would imply that it is very unlikely that such researchers ever actually did refer to or mean the same things when making predictions. The arguments I propose against SIT apply to both versions.

[4] This same distinction is made with respect to theories of reference by Philip Kitcher (1978).

[5] I would like to thank Paul Churchland, Eric Gampel, Peter Godfrey-Smith, Patricia Kitcher, Joe Mendola, Sam Mitchell, Edmund Mulaire, Graham Nerlich, and Stephen Stich for very helpful comments on earlier drafts of this paper. I owe special thanks to Philip Kitcher for sage advice and generous encouragement.

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