CONFIRMATIONAL HOLISM AND BAYESIAN EPISTEMOLOGY*

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Much contemporary epistemology is informed by a kind of confirmational holism, and a consequent rejection of the assumption that all confirmation rests on experiential certainties. Another prominent theme is that belief comes in degrees, and that rationality requires apportioning one's degrees of belief reasonably. Bayesian confirmation models based on Jeffrey Conditionalization attempt to bring together these two appealing strands. I argue, however, that these models cannot account for a certain aspect of confirmation that would be accounted for in any adequate holistic confirmation theory. I then survey the prospects for constructing a formal epistemology that better accommodates holistic insights.

1. Bayesian Epistemology. The central Bayesian requirement of rationality is that an agent's degrees of belief conform to the probability calculus. But probabilistic consistency falls short of providing a complete account of rational belief. Like deductive consistency, or any pure coherence condition on justified belief, probabilistic consistency does not guarantee that the agent's beliefs will be responsive to her experience in the way that rationality requires. An adequate account of the structure of justification must, therefore, incorporate an account of experiential learning.

The orthodox Bayesian account of learning from experience is the Strict Conditionalization model. The agent becomes certain of various propositions—that is, assigns them probability 1—directly, on the basis of experience. This acceptance of evidence then informs the agent's other beliefs indirectly: If the evidence provided by the agent's experience is captured by the agent's assigning probability 1 to evidential proposition E, the agent's new probability for any proposition H will be the same as her old probability for H given E.

In some ways, it is obvious that this model provides only a partial account of learning from experience, and thus only a partial account of

*Received June 1991; revised February 1992.

†I would like to thank Hartry Field, Richard Jeffrey, Mark Kaplan, Hilary Kornblith, Derk Pereboom, and a referee for *Philosophy of Science* for helpful discussions and correspondence on these matters, and for comments on earlier drafts of this paper.

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Philosophy of Science, 59 (1992) pp. 540–557

rational belief. It does not, after all, specify anything about direct experiential learning—about which experiences should make us certain of which evidential propositions. This sort of question is simply finessed by taking the direct learning as given. Questions about, say, which experiences (or, perhaps, which retinal irradiations) should make an agent certain of "That is green" are, perhaps, interesting questions, and even epistemological questions, but they do not seem to be the kind of questions appropriate to *formal* epistemology. They do not concern the distinctive logical or structural or cognitive aspects of justification.

It is these cognitive or structural aspects of justification that the orthodox Bayesian account purports to describe. It explains how the vast majority of our beliefs are justified by the interaction between evidential certainties and the structure of our belief system. The goals of the account, then, are in no way modest. If Bayesianism can give us a satisfactory account of the structural aspects of rational belief, it will have given us everything that could be desired of a formal epistemology.

Unfortunately, it has been persuasively argued that orthodox Bayesianism cannot account for much—if any—of what we learn from experience. The assumption that agents learn evidential propositions with certainty has widely been taken to be discredited. On the holist epistemological picture, in which even very observational propositions can be undermined by theoretical considerations, the assumption that experience furnishes us with evidential certainties is particularly implausible.

Richard Jeffrey (1965) considers an agent examining a cloth by dim candlelight. On the basis of this experience, the agent sharply raises his credence in the cloth's being green; but he also acknowledges that the cloth could be blue, or perhaps even violet. Clearly, the agent does not assign probability 1 to the proposition G that the cloth is green. Thus if this instance of experiential learning is to fit the Strict Conditionalization model, the agent's new credence in G must be the result of indirect learning by conditionalization on some other proposition E to which the agent did assign probability 1. But what would that other proposition be? The obvious candidates, such as "the cloth looks green or possibly blue or conceivably violet", are clearly too vague. They cover a wide range of different experiences that would justify a wide range of different probabilities for G. On the other hand, how else could the agent characterize his experience? No proposition seems to be available to the agent, made certain by the experience, and precise enough to capture the evidential import of the experience. Since this sort of situation is easily duplicated in countless examples of ordinary perceptual learning, orthodox Bayesianism cannot give an adequate account of learning from experience.

On Jeffrey's model of learning, experience *changes* the probability of some proposition, but need not make it certain. This initial change in

probability then affects the agent's other beliefs indirectly, via "Jeffrey Conditionalization", an elegant generalization of the Strict Conditionalization principle. The idea is roughly this: If the agent's experiential input is represented by a change in her probability for E, then her postexperiential probability for H should be a weighted average of two components: (1) her old probability for H given E, and (2) her old probability for H given not-E. The weighting reflects her new probability for E: The first component is multiplied by the new probability for E, the second by the new probability for not-E.

The cloth example, then, would be described as follows: As the result of the visual experience, the agent raises the probability of G to its new level. This new degree of belief in G becomes the input to Jeffrey's learning model. The agent's new probabilities are determined, via Jeffrey Conditionalization, from the agent's pre-experience probabilities plus this new probability for G. This model seems to reconcile the basic idea behind the orthodox model with some of the insights of contemporary epistemology, and it is now the most popular probabilistic model for experiential learning. Let us refer to it as the "liberal Bayesian" model.

2. Jeffrey's Colored Cloth Reexamined. In assessing the extent to which the liberal model succeeds in accommodating holist insights, I will begin with a variation on Jeffrey's cloth example. Suppose that a different agent, who is about to examine the same cloth under the same lighting conditions, has a certain background belief: She gives a relatively high probability to the proposition that she is a subject in a perceptual psychology experiment, in which the lighting has been manipulated to give misleading color impressions. Seemingly, in this case, the agent's background belief should affect the degree to which she raises her probability for G. Her visual experience does not warrant the same degree of confidence in G as it would have if she did not suspect that the lighting conditions were misleading. This sort of influence of "theoretical" beliefs on "observational" ones is, of course, typical of those frequently adduced in defense of confirmational holism.

This observation invites an obvious question: How should we represent the way in which the agent's background belief about lighting conditions affects her learning about the cloth's color? In fact, a parallel question arises for Jeffrey's original version of the example, for in Jeffrey's case, the agent's higher degree of confidence in G clearly depends on his assigning a relatively low probability to deceptive lighting. In general, we must see perceptual learning of the sort described by Jeffrey as being mediated by background beliefs rather than as simply being the product of the direct impact of experience on the proposition in question.

By what mechanism does the mediation take place? On the liberal

Bayesian model (as on the orthodox model) only one kind of mediation can be represented: mediation by conditional probabilities. Might the model be able to differentiate in this way between the agent in Jeffrey's example (let us call him "Jeff") and the agent in the variant example described above ("Joan")? We might suppose that, as a result of their different background beliefs about deceptive lighting, Jeff's conditional probability for *G given that the cloth looks a certain way* is higher than Joan's. Now suppose that the experience of seeing the cloth raises the probability of the proposition that the cloth looks that certain way. If we use Jeffrey Conditionalization to determine the new probabilities for G, we should get the desired result: that Jeff's postexperience probability for G is greater than Joan's.

The problem with this suggestion, however, should especially stand out when we have so recently been considering Jeffrey's argument against orthodox Bayesianism. For what exactly is the above-mentioned proposition "that the cloth looks a certain way"? It cannot be the proposition, for example, that *the cloth looks green or possibly blue or conceivably violet*. As Jeffrey has pointed out, this sort of proposition is much too vague; various different experiences fitting this description would justify various different levels of confidence in G. Nor does any other candidate spring to mind for precisely the reason Jeffrey gave in his discussion of the cloth case: Our language does not seem rich enough to individuate experiences with sufficient precision to capture their evidential implications. Thus the perceptual learning described in Jeffrey's cloth case cannot be fully accounted for even on the liberal version of the Conditionalization model.[1]

The problem seems to stem from a structural feature that the two Bayesian models have in common: Both models represent mediated learning as resulting ultimately from the initial effect of experience on the probability of some other proposition(s), and neither model can represent this initial effect of experience as mediated. But even if (*contra* strict versions of holism) some propositions could plausibly be taken to be affected by ex-

[1]The fact that the liberal Bayesian model does not account for the whole learning process has not gone entirely unnoticed, though I have seen little discussion by Bayesians of the philosophical implications of this fact. In a 1957 letter to Jeffrey (excerpted in Jeffrey 1975), Carnap complained that Jeffrey's new model failed to assess the rationality of the agents' postexperience degree of belief in the experiential proposition (G in our example). Levi (1967,1970) has more recently made a similar complaint, suggesting that the problem could be solved by allowing agents to regard revisable beliefs as absolutely certain. Hartry Field (1978) worried that Jeffrey's model could not naturally be supplemented by "input laws" describing the impact of various stimulations on experiential beliefs. Brian Skyrms (1975) writes, "This interaction between theory and observation, which determines the final probabilities which go into Jeffrey's rule, is a process for which we have no nice analysis" (p. 198). Carnap and Field were moved to attempt Bayesian-style alternatives to Jeffrey's model; these will be examined.

perience in an unmediated way (such as "this looks greenish"), these do not seem specific enough to account for the precise evidential effects of experience. This is why the liberal model is just as incapable as the orthodox model of providing an account of perceptual learning that accommodates the insights of holism.

Where does all of this leave Bayesian epistemology? I suggest that we are left with three options. First, we might dissolve the problem by showing that, after all, some epistemically basic propositions are assigned probabilities (though perhaps not probability 1) directly from experience, and are also rich and precise enough to capture the evidential force of experience. A second option would involve rejecting the demand that our learning theory account for the role of background beliefs in the learning situations described. Either of these options would allow us to rest content with the liberal Bayesian model.

In the next two sections, I will argue that neither of these options is wholly attractive. Thus a third option is worth exploring: developing a different formal model of learning, one that accounts for the epistemic role of background beliefs while avoiding the assumption that the probabilities of some propositions are determined directly by experience. I have no such account to offer; however, it seems to me that examining some attempts in this direction from the holist perspective can give us an idea of where the possibilities and problems in this direction lie.

3. Are There Epistemically Basic Uncertain Beliefs? Jeffrey's original colored cloth argument traded on the difficulty of finding sentences satisfying two conditions:

1. They must capture the evidential import of the relevant experience; and
2. We must be able to assign them probability 1 directly on the basis of the relevant experience alone.

This problem should seem familiar. "Strong foundationalist" epistemology has long sought to build experiential learning on the direct, certain deliverances of experience; and familiar objections so strong foundationalism have exploited the difficulty of doing this.

Some of the objections have focused on condition (2) above, denying the possibility of being *certain* of propositions such as "This is green", or even of "I am now appeared to greenly". It has been argued that implicit in the judgement that a certain appearance is green is the claim that this appearance is qualitatively similar to other things that are classified as "green". In classifying the present appearance, I am presupposing that I am classifying it in the standard way; and this presupposition may possibly be mistaken (see Reichenbach 1938, sec. 20, or Ayer 1952, 90–

93). This line of objection will be especially natural from the perspective of the holist picture of confirmation. No sentence, holds the holist, is tied so immediately to experience that our belief in it is entirely independent of the rest of our beliefs. Some of our beliefs are less directly dependent on theoretical considerations than others, but even at the limit of observationality—even for those sentences at the "periphery" of our theory—connections to other beliefs can undercut the force of experience (see Quine [1951] 1961).

Some epistemologists have tried to rescue strong foundationalism by positing a special class of basic beliefs that are immune from holistic influences. One might try to avoid entanglement in the web of belief by making one's basic propositions "non-comparative", perhaps holding that they were "demonstrative", their content being fixed by the appearance in some way that precluded error (see Chisholm 1989 or Pollock 1974). This line, however, has landed its proponents in difficulties roughly corresponding to failure to satisfy condition (1) above. "Purely demonstrative" beliefs, it is argued, fail to connect with other beliefs in the way that would be necessary for them to fulfill their intended evidential role (see Reichenbach 1938 or Williams 1977). The structure of this problem is strikingly similar to the structure of the problem Jeffrey posed for the Strict Conditionalization model.

(This line of argument suggests a possible answer to Jeffrey's challenge that I have not seen made on behalf of orthodox Bayesianism: taking ordinary perceptual learning to be grounded in some sort of demonstrative beliefs whose content is in part fixed by experience. Instead of the impossibly vague "the cloth looks green or possibly blue or conceivably violet", we would obtain our postexperience degree of belief in G by conditionalizing on the certain, precise "I'm appeared to *that* way". Such an account would, of course, not accommodate holism, but would, if successful, refute it; and as such, it is outside this paper's scope. I suspect, however, that such an account would encounter severe difficulties quickly. The Conditionalization model would seem to require that, before having the experience, the agent have some degree of belief in G conditional on a proposition whose content was fixed by the experience the agent had not yet had.)

Now how is all this relevant to the project of solving our present problem, which is supposed to infect the *liberal* learning-model? After all, the whole point of Jeffrey's liberalization of the orthodox model was to avoid reliance on certainties. Why should the power of traditional anti-certainty arguments be of any concern in solving the problem we found in the liberal model of learning?

This question may be answered by attending to the arguments the antifoundationalists have given for their conclusion. We have seen that on

the liberal account, mediated learning ultimately depends on initial learning involving sentences satisfying the condition that

1. they must capture the evidential import of the relevant experience.

In the liberal model, this initial learning is not represented as mediated by other beliefs. Thus if we are not simply to ignore mediation, the beliefs upon which learning ultimately depends will have to be produced directly. Our directly affected sentences must therefore satisfy a weakened version of (2), which eliminates the requirement of certainty, but requires instead that

2′. we must be able to assign them their new probabilities directly, on the basis of the relevant experience alone.

The reason that any sentence suitably robust to satisfy (1) could not be learned with *certainty* was, at bottom, that our knowledge in such cases depended on various (fallible) presuppositions, or connections to other parts of our theory. But this is just to say that such knowledge is not *direct* in the sense relevant here: Our probabilities for such sentences are not determined "on the basis of the relevant experience alone". Thus the traditional arguments against the certainty of these sentences essentially *proceed by way of* showing that the justificatory connections between them and experience are not direct. What prevented (2) from being satisfied was just that the weaker (2′) was not satisfied.

Apparently, then, the epistemically basic uncertain propositions the liberal account requires will be no easier to find than those required by orthodox Bayesianism. The familiar holistic considerations tell just as strongly against the possibility of constructing a satisfactory Jeffrey-style model of learning as they tell against the possibility of constructing a satisfactory model based on Strict Conditionalization.

4. Why Worry about Background Beliefs? So far, I have simply presupposed that the "problem" described in section 2 really is a problem—that our formal epistemology *should* be able to account for the way in which learning is informed by our background beliefs. Surely this assumption might be questioned.

Consider the orthodox version of the Conditionalization model. It tells us how our beliefs should be affected by our becoming certain of an evidential proposition, but it does not tell us anything about which experiences, or which sensory stimulations, should make us certain of which evidential propositions. Questions about the processes behind the inputs to the Strict Conditionalization model may well carry epistemological interest, but the task of characterizing those processes is naturally taken to be outside the scope of the formal account. Can we not simply say the

same thing about the problem of characterizing the processes behind the inputs to the liberal Bayesian account?

It seems to me that we cannot—at least not without paying a significant philosophical price. To see why, let us compare the scopes of the orthodox and liberalized versions of Bayesianism. The orthodox model, while it could not purport to completely describe the way our beliefs should be derived from our experiences, did purport to account for a certain substantial and well-defined domain. It purported to account for the cognitive or structural aspects of justification: It described how our beliefs should relate to one another, and, in particular, how the acquisition of new beliefs should be conditioned or mediated by the beliefs we already have. These are the aspects of learning that comprise the intended subject matter for inductive logic. It is these aspects of learning—albeit in heavily idealized form—that the orthodox Bayesian model purported to describe.

In this respect, the intended domain of the orthodox account contrasts sharply with the domain that we are considering assigning to the liberal account. For the aspect of learning we now contemplate excluding from our model's scope involves the way certain of our present beliefs condition or mediate the acquisition of new beliefs. If we exclude this aspect of justification from our model's domain, we will have placed an important cognitive or structural aspect of justification outside the area our theory purports to describe.

We may put the point in terms of the cloth example as follows: The way that Joan's belief about deceptive lighting should influence her postobservation probability for G seems no less cognitive or logical than the probabilistic-evidential way Joan's beliefs should influence one another in general. In saying that her background beliefs should influence her postobservational degree of belief in G, we seem to be holding her up to some sort of cognitive standard of rationality, the kind of standard which formal epistemology generally attempts to capture. If we simply make Joan's postobservation probability for G the *input* to our learning model, we will have bypassed an important part of what formal epistemology seeks to explain.

Liberal Bayesianism is thus not simply an elegant generalization of orthodox Bayesianism, a pure improvement which merely removes some gratuitous idealization. It removes idealization, but at a price. The additional cases covered by the liberal model are not covered in the same way; and consequently, the account as a whole must be given a different philosophical interpretation. In particular, we cannot be as sanguine about taking the processes behind the model's inputs as "beyond the intended scope" of our epistemic theory. We may, of course, fail in the end to understand the structure of holistic confirmation well enough to capture it formally; in that case, we might be well advised to settle for the lim-

itation of scope that liberal Bayesianism imposes. If we do so, however, we should realize that we are resigning ourselves to a dramatic lowering of our philosophical sights.

It was, I think, essentially just this lowering of sights that prevented Carnap—who was uncomfortably aware of the level of idealization in the Strict Conditionalization model—from embracing Jeffrey's way of escaping that idealization. Jeffrey responded that the project Carnap had in mind was an impossible one. Carnap's project, he held, was committed to "empiricism", which Jeffrey saw as involving "the insistence on isolating the experiential element in knowledge from the logical element—at least in principle" (1975, 48). To Jeffrey, this empiricist program looked unworkable.

This comment of Jeffrey's raises important questions. If it is intrinsically impossible to give a full account of the structural aspects of learning, then lowering our sights is perhaps regrettable, but fully appropriate—indeed, necessary. But *is* giving such a full account impossible? Although it is hard to imagine how to answer this question definitively (without actually producing an account of the sort in question), in the next sections I will look briefly at the prospects for constructing such an account.

5. Does Holism Preclude Constructing an Adequate Account? Let us begin by considering Jeffrey's suggestion that the program Carnap envisioned would involve an impossible separation between the experiential and logical elements of knowledge. In particular, we might ask two questions: (1) In what sense is separating the experiential and logical elements of knowledge impossible? and (2) In what sense do these elements need to be separated in order to give a full account of the cognitive or logical aspects of learning?

Let us first consider the claim that the experiential and logical elements of knowledge cannot be separated. Taken one way, this claim is a familiar part of holistic pictures of confirmation, according to which all of our beliefs are susceptible to both pressures from experience and pressures from interconnections with other beliefs. On this picture, no beliefs are "purely logical" in the sense that their justification is entirely independent of experience; and, more importantly for our purposes, no beliefs are "purely experiential" in the sense that they depend for their justification purely on experience. This, then, is one sense in which holism does preclude isolating the experiential element in knowledge from the logical element.

Orthodox Bayesianism does, it seems, attempt to isolate the experiential element in knowledge in precisely this way, by postulating a special class of purely experiential beliefs. And as we saw, the account runs into

severe difficulties, of exactly the sort a holist would expect. Moreover, we have also seen that these difficulties are not avoidable by the liberal Bayesian expedient of relaxing the classical certainty requirement for purely experiential beliefs. Thus, if formulating a satisfactory formal epistemology required the postulation of some set of purely observational beliefs (be they beliefs with certainty or beliefs of some lower degree), then I think that we would have a clear theoretical reason for pessimism about the prospects for the project.

Nevertheless, I see no reason to think that formal epistemology should require separating the logical from the experiential elements of knowledge in *this* sense. Rather, what seems to be required is a different sort of isolation of the experiential: a theoretical isolation, in which the experiential inputs to the learning model are independent of the structure of the agent's beliefs. Positing purely experiential beliefs, while it is one way of accomplishing this theoretical isolation, is not the only conceivable way. Thus holism has not as yet provided us with any clear reason for thinking the project of constructing a full formal epistemology to be unworkable.

Consider the "fabric" metaphor encountered in Quine's writings. It suggests, albeit in a vague and informal way, that experience shapes our system of beliefs in some way that does not require the interposition of special beliefs held on the basis of experience alone. On Quine's picture, an experience's effect on any of an agent's beliefs is influenced from the beginning by the other beliefs in the agent's system. Nevertheless, it is experience (or, in later Quine, sensory stimulation) that is ultimately responsible for shaping the fabric of belief. Nothing in this informal description suggests any difficulty in principle with theoretically isolating the experiential input to the belief system. In fact, the picture seems to embody just this sort of isolation informally when it talks of experience having an impact or putting pressure on the fabric: Our belief system is one thing, and our experience is another. (Indeed, it is a bit hard to see how any reasonable epistemological picture could avoid isolating the experiential element in knowledge in this sense.)

The informal picture does suggest a *constraint* on designing the inputs to an adequate formal learning model. If the inputs are to characterize the distinctively experiential contribution to knowledge, and if none of our actual degrees of belief are purely experiential, then the inputs to our model should not be chosen from among the agent's actual degrees of belief. This constraint, though it is clearly violated by both orthodox and liberal Bayesianism, is not obviously impossible to satisfy.

Apparently, then, epistemological holism provides no quick or obvious reason to think that constructing a full account of the cognitive or logical aspects of learning is impossible. Rather, the holist picture seems to give

us an informal model for constructing such an account. In the next section, I will examine briefly what such an account might look like.

6. What Might a Holist Formal Epistemology Look Like? Let us start by looking at two related attempts—by Carnap and by Field—to construct learning models that did not use the agent's postexperience degrees of belief as inputs. Perhaps the most natural of these is the one suggested very briefly by Carnap, in the above-mentioned letter to Jeffrey (Jeffrey 1975). Carnap envisioned representing experiential input by a number attached to the experientially affected sentence. The number was to "indicate the subjective certainty of the sentence on the basis of the observational experience" (ibid., 42). Thus in the colored cloth case, instead of using the agent's *actual* postobservation degree of belief as our input, we would use a number representing the degree of belief in G that *would be* warranted by the agent's visual experience alone. We then would look for a way of computing the agent's rational postobservational degree of belief in G (or any other proposition) from this number along with the agent's pre-experience belief function.

Such a model would neatly avoid the problem inherent in liberal Bayesian learning theory. The model's input is not the product of a rational learning process mediated by other beliefs, so we have not bypassed part of our intended explicandum. Moreover, the model seems to give us a way of isolating or characterizing the experiential element in learning without postulating that the agent bases any of her actual beliefs directly on experience. Unlike the classical Bayesian account, this model would avoid the demand that experience furnish us with certainties.

At first, this idea seems natural when it is seen in light of the holist picture of confirmation. The cash value of saying that experience puts pressure on beliefs in our system seems to be that certain experiences have a tendency to increase (or decrease) our degrees of belief in certain propositions. This tendency of the experience represents its contribution to knowledge; and it is this tendency which the Carnapian inputs attempt to capture.

But Carnap discovered difficulties as soon as he considered which rule should be used for computing the agent's postexperience probabilities from her pre-experience probabilities plus the input. Adapting Carnap's example to our cloth case, let us ask: Suppose that the degree of support an agent's glimpse of the cloth lends to G is 0.8. Suppose that the agent's probability for G on the rest of her evidence is 0.9. What should the agent's postexperience probability for G be? It should not be simply 0.8—that would ignore all the rest of her evidence. Similarly, it should not simply be 0.9—that would ignore the new evidence. Carnap's guess was that the postobservation probability should be greater than 0.9 since the

experience should presumably count as additional evidence in favor of G; however, he saw no particular value as clearly mandated. Carnap reports that he grew so discouraged with the project of formulating a rule for using his inputs that he gave up trying without making a serious effort. Being unwilling to accept the limited scope of Jeffrey's learning model, he settled for the idealizations of Strict Conditionalization.

Field, however, ventured beyond this point. Like Carnap, he used numbers to represent the direct effect of experience on sentences, but he rejected the notion that these numbers should be seen as representing the probability of the sentence on the experience alone. To each pair of a stimulation and a directly affected sentence, Field assigned a number representing "the degree to which the stimulation affects [the sentence]" (1978, 362). These input numbers are then used, along with the prestimulation probabilities for the directly affected sentences (such as G in our example), to arithmetically determine the proper poststimulation probabilities for those sentences.[2] Field's model thus gives a fairly straightforward answer to the question Carnap found himself unable to answer. It then goes on to calculate the postobservation probabilities for other sentences from the new probabilities for the directly affected sentences, using Jeffrey Conditionalization.

Field's model turned out to have highly unintuitive consequences: Daniel Garber (1980) showed that on this model repetition of the same relatively uninformative observation quickly eventuates in near-certainties. Jeffrey (1987) tentatively suggests that Garber's problem might be solved by seeing repetitions of physiologically identical observations as phenomenologically distinct (due to the influence of memory). But from our perspective, this strategy would be misguided. The reason that repetitions of the same experience do not create certainty is that after adjusting our belief to accommodate the first experience, we (rationally) treat repetitions of the same experience differently. This is a paradigmatically *cognitive* effect, not a phenomenological one. Not that we do not have the same experience again, but rather our background beliefs do not allow repetitions of the same experience to have the same effect

[2]When a stimulation affects a single sentence G, the value of the input number α may be obtained from an agent's probabilities for G just before and just after an occurrence of the stimulation in question. Where p is the probability before the stimulation, and q the probability after,

$$\alpha =_{df} (1/2)\log ((q/p)/((1 - q)/(1 - p))).$$

Given a value for α and any value p for the pre-experience probability of G, the proper probability q for G after experiencing the stimulation is calculated as follows:

$$q = (pe^{\alpha})/(pe^{\alpha} + (1 - p)e^{-\alpha}).$$

When more than one sentence is directly affected, the input numbers are applied to conjunctions of these sentences (or their negations). For details, see Field (1978).

on our beliefs. Thus I would see Garber's difficulty as arising from the general problem I have been discussing.[3]

From a holist point of view, then, it is not surprising that Field's approach ran into trouble. Consider first the simple case where a stimulation directly affects just a single sentence (suppose it is G) and its negation. In that case, the new probability for G is completely determined by the old probability for G and the input number associated with the stimulation. However, if the effect of experience on even "observational" sentences such as G should be mediated by background beliefs, we *should not* be able to determine the agent's postobservation probability for G in this way. To illustrate, let us for the moment treat the Jeff and Joan case as if G were the only directly affected proposition. Clearly, there is no reason to suppose any differences between Jeff's and Joan's experiential inputs or in their preobservation probabilities for G. Yet the difference in their background beliefs about deceptive lighting should produce a difference in their postobservation probabilities for G. In general, giving any solution to the problem as described by Carnap begins to look like a step in precisely the wrong direction.

Now it might be objected that, in the Jeff and Joan case at least, treating G as the only directly affected proposition would not be realistic. Field has pointed out (in correspondence) that the proposition that the cloth *looks* green may plausibly be taken to be directly affected, along with the proposition G that it is green. If we treat the case this way, then, since in the general case Field's model applies input numbers to *conjunctions* of directly affected propositions, it would calculate Jeff's and Joan's poststimulation probabilities on the basis of the pre-experience probabilities of conjunctions such as "the cloth looks green and it is green". Since Jeff and Joan have different theoretical beliefs about the likely relations between apparent colors and real colors, we cannot assume that their probabilities for these *conjunctions* will be the same, even if their probabilities for the conjuncts are identical.

Handling the case in this way, however, raises serious questions about the philosophical interpretation of the formalism. One can always provide

[3]Some of the informal remarks in Garber's note bear on these themes. On Field's model, the degrees of belief fed into the Jeffrey Conditionalization principle are explicitly recognized not to be purely experiential since they depend on the prior probabilities as well as the input numbers. Garber argues that this does not jibe with the intuitive picture behind Conditionalization principles—that they transmit direct effects of experience.

Some of what Garber says suggests a further claim: that to abandon the foundation of purely experiential beliefs is to lose the distinction between belief changes that are direct effects of experience and those that are indirect effects. This latter claim (which I am not sure that Garber intends) I would reject: On one natural holist picture, experience puts direct pressure on peripheral beliefs, and changes in other beliefs are (indirectly) caused by the pressure on the peripheral beliefs, yet no beliefs are held purely on the basis of experience.

for the possibility of distinguishing between agents with distinct probability distributions simply by expanding the set of propositions taken to be "directly affected by experience". The question is whether this can be done while preserving the intuitive power of the account. While it is intuitively plausible that experience would directly affect the proposition that the cloth looks green, as well as the proposition that the cloth is green, it is not nearly so plausible that experience directly affects the probability of the conjunction (keeping in mind that the probability of the conjunction is not a function of the probabilities of the conjuncts).

Moreover, an independent problem arises with bringing in phenomenal reports to capture the evidential relations between apparent and actual colors. Recall the difficulty Jeffrey found with handling his cloth case by Strict Conditionalization: Phenomenal reports are not sufficiently precise to capture the evidential import of experience. If phenomenal reports by themselves are too vague to satisfactorily capture the way the cloth looks, then why should we think that conjunctions including these same vague phenomenal reports will be capable of capturing the evidential relations between the way the cloth looks and its actual color? If they cannot, our problem cannot be solved in the envisioned manner. The basic problem is that we have seen no reason to believe that the postexperience probability of a directly affected proposition should be a function of just the pre-experience probabilities of directly affected propositions (or their conjunctions) and the quality of the experience itself.

This perspective, I think, throws some light on Jeffrey's discussion of Field's input numbers. Jeffrey (considering a case in which a single proposition is directly affected) points out that Field's input numbers are equivalent to the ratio obtained by dividing the new odds on the directly affected proposition by the pre-experience odds on that same proposition. Jeffrey explains the idea as follows (here P represents the pre-experience probability function, Q the postexperience probability function, and E is the directly affected proposition):

> The thought is that the transition[ ] from P(E) to Q(E) . . . [is] the result[ ] of combining [the input number] with your ambient judgments when the inputs are received. The ratio . . . is meant to dissect out of P(E) . . . the bit that's responsible for that transition. . . . (1987, 395)

In other words: The new probability for E cannot itself represent the contribution of experience because it is a product of the experience *plus* the agent's pre-experience probability function. So we "dissect out" the contribution made by the pre-experience probabilities by dividing the new odds on E by the pre-experience odds on E.

The problem with this suggestion is that dividing the new odds by the

old odds can dissect out the contributions of the old probability function only insofar as those contributions may be captured by the prior probability *for E itself*. But in fact, the influence of the old probability function is more complicated than that. As we have seen, elements of the old probability function other than the probability for E can also rationally influence the effect that a given experience has on the final probability for E.

It seems, then, that holist epistemology places another important general constraint on the construction of an adequate model of experiential learning. This constraint is independent of the particular way we represent the experiential input. We saw earlier that the postexperience probability for even an "observational" proposition like G must depend on more than the agent's experiential input. Now it is equally clear that taking the experiential input together with the proposition's pre-experience probability is still not sufficient to determine the proposition's postexperience probability. This problem cannot be solved by adding in pre-experience probabilities for conjunctions of other directly affected propositions. The lesson of holism is that postexperience probabilities for even "observational" sentences must depend on the agent's "theoretical" beliefs as well. Learning theory which does not take these other beliefs into account is intrinsically incapable of giving us a complete account of the structural aspects of justification.

There is also, I think, at least one more way in which our construction of a formal learning theory may be informed by the holist picture of confirmation. Let us look more carefully at Quine's metaphorical description of the way experience informs our beliefs: Our fabric of belief "impinges upon experience" ([1951] 1961, 42), then our beliefs are "governed by a delicate balancing of varied forces transmitted across the fabric of sentences from remotely relevant stimuli" (1960, 18). This suggests that experience or sensory stimulation informs our beliefs by exerting a kind of *force* on the more observational ones. This force is what we must seek to capture in the inputs to our learning model.

Now physical forces have both magnitude and direction. I suggest that a prima facie case can be made for something analogous being true in the case of experiential impacts upon our belief system. Let us consider the effects of various different experiences in our colored cloth example. Assume that the agent's pre-experience probability for G is fairly low, and that he has no reasons to be suspicious about the lighting. A long, clear, centrally green-appearing look would (ceteris paribus) have a strong tendency to make the probability of G high. A chromatically similar but much briefer glimpse would also raise the probability of G, but not by so much. Intuitively, the force of the former experience has greater magnitude; it has a greater tendency to produce change in belief. This mag-

nitude is perhaps what best corresponds to Field's inputs, which can take any real value, and his interpretation of those inputs as representing "the degree to which the stimulation affects [the sentence]".

Clearly, however, different experiences not only affect a given proposition to different degrees, they affect a given proposition in different directions. A long, clear centrally red-appearing look would have a strong effect on G, but it would be to lower its probability, not to raise it. This suggests at least two directions in which experience can push beliefs: toward 1 or toward 0, but the situation is more complicated than that. Consider a blue-green-appearing look at the cloth. If the agent's pre-experience probability for G is low, the experience should raise it. But we cannot see this as showing that the experience has a positive effect on G in general; for if the agent's pre-experience probability for G is high, the experience should lower it. With examples like this in mind, it seems arbitrary to insist that the direct effect of an experience on a belief must (everything else being equal) be to push it toward one extreme value or the other. Any value between 0 and 1 would seem to be a possible "direction" toward which the probability of an observational proposition might be pushed. The direction of the force of the experience perhaps corresponds best to Carnap's input numbers between 0 and 1, and to his interpretation of them as indicating the "subjective certainty of the sentence on the basis of the observational experience".

The foregoing reflections suggest that the inputs to experiential learning may require more complex representation than one might at first have supposed. A single number attached to a sentence cannot naturally represent both the magnitude and direction of the force applied to a belief by experience. Thus the inputs to an adequate model of experiential learning may have to attach a pair of numbers to an observational sentence to represent experiential impact, even when just one sentence is directly affected.

Moreover, even in the fairly simple sorts of cases we have been discussing, the contribution of experience will not be fully representable as a two-dimensional impact on a single sentence. Assigning a magnitude and direction to the force that a certain glimpse exerts on G does not convey the information that the experience exerting the force was visual. But this information must be part of what determines the postobservational probability for G since the effect of the background belief about deceptive lighting is relevant only if the experience is visual. Thus it turns out that taking holistic considerations into account requires building a great deal of complexity into the inputs of even the simplest instances of experiential learning.

It seems, then, that although the informal holist picture of confirmation does not immediately preclude the possibility of developing a full formal

account of belief justification, it pushes that project in the direction of much greater complexity. The additional complexity required in representing experiential inputs, and in using background beliefs along with these inputs to determine postobservational probabilities, is daunting. At this stage in the investigation, I believe that it is unclear whether the complexities that holism seems to require will in the end prove prohibitive.

7. Conclusion. Taking confirmational holism seriously poses a difficult challenge to formal epistemology that is not met by either classical or liberal Bayesianism. Holism does not undermine the motivating insight behind probabilistic epistemology—that reasonable apportioning of one's degrees of belief is a central component of rationality. However, holistic considerations do seem to pose insuperable obstacles to current Bayesian attempts to account for learning from experience.

True, liberal Bayesianism accommodates the insight that we are uncertain of even the most "observational" of our beliefs. But in a sense, the most significant difference between classical and liberal Bayesianism is not that the latter allows for learning that does not originate in certainties. The most significant difference is that the inputs to the liberal model of learning are themselves products of a learning process mediated by the agent's beliefs. Thus the liberal model cannot hope to fully account, even in an idealized way, for the structural aspects of experiential learning; it accommodates holist-inspired doubts about the certainty of observation, but at the cost of precluding representation of the very holist mechanisms that prompted its creation. This is not, of course, to deny that the model captures an important aspect of confirmation. But until we find a more adequate formal epistemology—a system that fully represents the structural aspects of belief justification—we must understand the scope and limitations of the partial account we do have.

The project of constructing a formal epistemology which incorporates the insights of confirmational holism into a rigorous structural description of the way experience informs rational degrees of belief may or may not prove tractable in the end. Although our reflections suggest that an adequate formal epistemology will have to be significantly more complex than the accounts we have today, this leaves open the possibility that we will eventually understand justification well enough to express its structural aspects formally. Even if that possibility does in the end come to be foreclosed, we may at least aspire to better comprehend the barriers to our understanding.

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