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Susceptibility to the Müller-Lyer Illusion, Theory-Neutral Observation, and the Diachronic Penetrability of the Visual Input System

Robert N. McCauley and Joseph Henrich

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Jerry Fodor has consistently cited the persistence of illusions—especially the Müller-Lyer illusion—as a principal form of evidence for the informational encapsulation of modular input systems. Fodor proposed that these modules' stereotypical deliverances about how the world appears could serve as a theory-neutral observational foundation for (scientific) knowledge. For a variety of reasons Fodor rejected Paul Churchland's putative counter-examples to these mental modules' cognitive impenetrability. Fodor's discussions suggest that demonstrating modules' cognitive penetrability would hinge on showing that because subjects either (a) acquire some explicit theory or (b) gain wider perceptual experience, they would, in the synchronic case, very quickly cease to experience the illusion or, at any rate, experience a mitigated version of it. Diachronic penetration, by contrast, would involve processes that deliver one of these outcomes over a decidedly longer period. Marshall Segall, Donald Campbell, and Melville Herskovits' (1966) research across seventeen cultures shows that culturally influenced differences in visual experience during the first two decades of life substantially affect how people experience the Müller-Lyer stimuli. In some of the societies most people were virtually immune to the illusion. Such findings call Fodor's showcase evidence for the cognitive impenetrability of the visual input system into question and, thereby, threaten to block the path to the theory-neutral, observational consensus that he scouts.

Keywords: Müller-Lyer Illusion; Cultural Differences; Cognitive Impenetrability; Modularity; Domain Specificity; Theory-Neutral Observation

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1. Introduction

Naturalists hold that attention to, respect for, and coherence with critical findings in the empirical sciences abet philosophical proposals. Moreover, the border between high-level scientific theorizing and the speculations of some naturalistically inclined philosophers in some fields has become increasingly porous.[1] In such a milieu it should come as no surprise that naturalists search the newest experimental studies in relevant empirical sciences for results that seem to bear on philosophers' various pronouncements about knowledge, language, and mind.[2] Occasionally, though, findings of interest arise not from current scientific studies but rather from earlier scientific work that was overlooked in the original philosophical discussion. That is what we will be up to here, specifically examining long-standing findings about the Müller-Lyer illusion that philosophers have neglected.

The publication of Jerry Fodor's paper "Observation Reconsidered" (1984/1990b)[3] occasioned the dispute on which we shall focus. There, offering yet another volley in a debate that has raged in the philosophy of science for decades, Fodor defends the possibility of theory-neutral observation in science. Fodor's case presumes his account of human cognitive arrangements in *The Modularity of Mind* (1983) where he offers a systematic treatment of the functioning and features of mental modules.

Modules, in Fodor's view, are special purpose mechanisms that are situated at the front-end of perception. On nearly all counts these modular "input systems" stand in striking contrast to more central cognitive processes concerned with such things as reasoning, analogy, and even perceptual judgment (1983, p. 73). Fodor countenances only six domains in which he expects modular arrangements (though there may be various specialized modules within each domain) (p. 47). Five of these domains correspond to the five sense modalities and the sixth concerns the apprehension of language.[4]

Fodor rejects the modular accounts of many central processes that have become popular over the last decade or so (e.g., Pinker, 1997). His most decisive objection (2000, pp. 22–39) concerns the global character of abductive and other forms of non-demonstrative inference, i.e., exactly the sorts of inferences that modularized *central* processors would have to perform regularly. Attributing these inferences a global character is to say that the systems that perform them must have entry to all—or nearly all—of our beliefs. The problem, Fodor argues, is that modules are "informationally encapsulated." They not only do not enjoy *pervasive* access to the wide array of beliefs that we hold about the world, they generally enjoy *little, if any*, access to them.[5] The mind's input systems are, to use Zenon Pylyshyn's (1984) alternative description, cognitively impenetrable. Hence, they are not at all likely to be capable of carrying out such inferences with even a modicum of success. Hence, Fodor argues, central cognitive processes are not at all likely to be modular.

For Fodor the general inability of central systems to feed information back to the perceptual modules contributes to the relative rigidity of those modules' functioning and to their stereotypical deliverances—to the central systems—about how the world appears. Those stereotypical deliverances result from hypotheses with which these

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perceptual modules come equipped to manage the stimuli in their proprietary domains. These hypotheses concern what Fodor calls the "observable properties of things" (1984/1990b, p. 249). The empirical evidence Fodor cites most frequently in support of informationally encapsulated perceptual modules concerns the *persistence* of perceptual illusions. Fodor emphasizes that no matter how insightful the scientific theories we consciously hold may be, some perceptual illusions simply will not go away.

Fodor intends, here, to distinguish *observation*, which is constituted by the rigid outputs of the perceptual modules, from *the fixation of perceptual belief*, which is a global process that our central systems carry out by assessing those modules' outputs in the light of our relevant knowledge. In short, observation is generally un-penetrated by our conscious cognitive commitments. Fodor contends that this is what purchases a theory-neutrality of observation, which he wishes to recruit as a ground for explicating scientific consensus. Even though scientists may espouse opposing theories, they can, nonetheless, frequently agree about experiments that would help decide between those theories and about the observational descriptions of those experiments' results, since "the way one sees the world is largely independent of one's theoretical attachments" (1984/1990b, p. 250). Fodor initially aimed to resist so-called "New Look" accounts of perception in psychology (e.g., Bruner, 1957) and the philosophy of science (e.g., Churchland, 1979), but, as his subsequent comments have consistently indicated, the prominence of such positions in contemporary philosophy (especially) continues to vex both him and Granny.

On the views of perception that Fodor is out to resist, (theoretical) *conception* is capable of penetrating *perception* thoroughly. Theoretical commitments infiltrate observation. Consequently, theory-neutral observation is impossible, and scientists must decide between competing theories on grounds that are pragmatic and holistic at best—grounds that Fodor finds insufficient for a satisfactory defense of scientific rationality.

With the goal of undercutting Fodor's case for theory-neutral observation, Paul Churchland (1988/1989) advances both conceptual arguments against theory-neutrality and empirical arguments aimed at undercutting the ability of our experiences with perceptual illusions to support the informational encapsulation of perceptual input systems. Although Churchland (1988/1989, p. 262) argues for the *possibility* of evidence of diachronic cognitive penetration concerning Fodor's favorite example, viz., the Müller-Lyer illusion, he, in fact, supplies evidence about a different perceptual illusion (and about ambiguous figures).

In reply to Churchland's conceptual objections, Fodor (1988/1990a) clarifies and qualifies his position in ways that seem to diminish the stakes of their epistemological disagreements. More importantly for our purposes though, Fodor rejects Churchland's *empirical* objections as either irrelevant or exceptional, and the debate has not progressed much since for want of further empirical evidence that might circumvent these replies. Apparently, what critics need is evidence of diachronic cognitive penetration of the putatively encapsulated input systems that inform our susceptibility to *persistent* illusions such as the Müller-Lyer, which

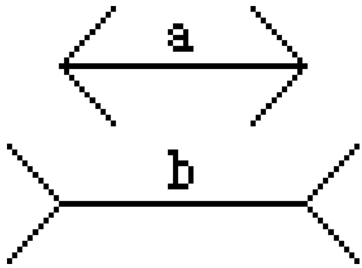

Figure 1 The Müller-Lyer Illusion. The lines labeled '*a*' and '*b*' are the same length. However, typical "Western" subjects perceive line *b* as longer than line *a*.

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Fodor and Pylyshyn (1999, p. 344) have *repeatedly* cited as an illustration that is *not* a special case. (No one, to our knowledge, has provided evidence for the synchronic cognitive penetration of the visual input system with respect to the Müller-Lyer stimuli.)

Diachronic penetration contrasts with the synchronic penetration of those input systems. Because subjects either (a) acquire some explicit theory (that has implications for their demonstratively illusory experience with some stimulus),[6] or (b) gain wider perceptual experience including, possibly, wider experience with the illusion-inducing stimulus and, presumably, thereby obtain a new implicit conception of it,[7] or (c) both, they would, in the case of synchronic penetration, *instantly* or at least very quickly cease to experience the illusion or, at any rate, experience a mitigated version of the illusion—e.g., the perceived disparity between the lines in the Müller-Lyer illusion (see Figure 1) would measurably decrease. *Diachronic* penetration, by contrast, would involve processes that deliver one of these two outcomes *over a decidedly longer period of time*. Given the vagueness of this temporal criterion, the distinction between synchronic and diachronic penetration is not a clean cut. Still, since neither party objects to how the other uses these terms, Fodor and Churchland seem, at least, to agree that effects occurring within a few seconds after attaining a novel perceptual or intellectual perspective would qualify as synchronic penetration, while those that only emerge after weeks or more would count as diachronic.[8] It is less clear how to decide about intermediate time frames, but neither Fodor nor Churchland seems troubled by the notion that cases might fall along a continuum.

Churchland cites the impact of musical training on perception as an illustration of cognitive penetration. Fodor's (1988, 1990a) reply that Churchland must show that "it's learning the theory (as opposed to just listening to lots of music) that alters the perception" (p. 260) might suggest that Fodor only recognizes the penetrability (whether synchronic or diachronic) of perception by consciously held beliefs or theory; i.e., that Fodor only countenances the sort of cognitive penetration represented by item (a) above—with, of course, the aim of mostly ruling it out.

That suggestion, however, would be misleading. In fact, Fodor not only allows for the possibility of cognitive penetration of the second sort (represented by item

(b) above—again, for the purpose of ruling it out), he *must* both allow for it and rule it out for his informational encapsulation thesis to possess much interest. The following four considerations will help to make this clear. First, in the passage in question, there is no reason to think that Fodor's response concerns anything other than what conditions *Churchland's specific argument* (concerning training in music theory) must meet to make his case for the cognitive penetration of perception by consciously held beliefs or theory. His aim is not to say anything about cognitive impenetrability in general.

Second, Fodor, at other points (e.g., 1984/1990b, p. 248), seems to recognize a less exacting notion of cognitive penetrability that squares with the characterization in item (b) above. Fodor entertains the possibility that simply having particular experiences would suffice for cognitive penetration, if those experiences subsequently lead to alterations in our perception of the stimuli responsible for what, heretofore, had been regarded as persisting illusions. As we shall discuss briefly in the next section, ecological realists' research has demonstrated such effects for a variety of illusory stimuli.

Third, given that the overwhelming majority of human learning involves implicit, non-propositional representation (Fiske, 2001; Lancy, 1996), claims about the informational encapsulation of perceptual modules are of considerably less interest, if all Fodor means by ruling out their cognitive penetrability (whether synchronic or diachronic) is ruling out the penetration of perception by beliefs or theory we hold consciously.

But finally and most importantly, if Fodor's informational encapsulation thesis does not mostly rule out this second form of cognitive penetration as well, then the thesis would fail to rule out all sorts of possibilities for all sorts of perceptual variation both across cultures and between individuals, which: (1) Fodor rejects, (2) everyone has interpreted Fodor to reject, and (3) Fodor *must* reject to proffer a compelling case for theory-neutral observation.

After briefly examining Fodor's account of input systems and their informational encapsulation and sorting through some of the epistemological fallout from the conceptual side of the Fodor-Churchland exchange in §2, we shall explore their mutual recognition of the vital role that the facts about perceptual illusions play in this debate. It seems to follow from comments that Churchland *and Fodor* (1988/1990a, p. 258) make that they agree that *evidence of some diachronic penetration of an input system responsible for susceptibility to a persistent illusion would suffice to block the path to theory-neutral observation that Fodor scouts*. It would also seem to raise notable problems for Fodor's uncompromising nativism about the systems in question, i.e., for Fodor's insistence that how and that input systems are informationally encapsulated are innately specified. He maintains that they are endogenous features of the human cognitive system that are, if not largely fixed at birth, then, at least, genetically pre-programmed; such reliably developing systems are triggered, rather than shaped, by the newborn's subsequent experience.

In §3 we consider evidence that neither Fodor nor Churchland have discussed. Cross-cultural research carried out four decades ago, i.e., *before* Fodor and

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Churchland's exchange, looked at developmental and cultural variability in the strength of five visual illusions, including the Müller-Lyer. In fact, Marshall Segall, Donald Campbell, and Melville Herskovits' (1966) findings provide evidence not only of variability across development with respect to the allegedly endogenous hypotheses of the visual input system responsible for our susceptibility to the Müller-Lyer illusion, but also of cultures in which many adults are not, in fact, susceptible to the illusion. In the final section, we shall argue that these findings pose problems for Fodor's consistent appeals to the persistence of the Müller-Lyer illusion as evidence for the informational encapsulation of the visual input system and, thus, for his arguments for establishing any substantial theory-neutrality of observation. They also at least point to a set of possible arrangements concerning visual observation among adults that *none* of the positions we will consider will find completely welcome.

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2. Fodor and Churchland Debate the Cognitive Penetrability of Perceptual Input Systems

Fodor (1983, pp. 47–101) highlights nine characteristics of mental modules. Modules are, first, *domain specific*. They are specialized mechanisms for handling *specific*, common, but complex problems humans face in making sense of the world, and their various operations are triggered by particular sets of stimuli characteristic of the (respective) domains they manage. Second, their operations are *mandatory*. These input systems function like cognitive reflexes. As Fodor notes, these input systems are "inflexibly insensitive to the character of one's utilities. You can't hear speech as noise *even if you would prefer to*" (1983, p. 53). Third, central systems have extremely *limited access* to the representations that these input systems compute, unless memory is not at all an issue. If we are concerned with knowing the time, then we are unlikely to remember, quite literally, a few seconds later what the numerals on the face of the clock looked like—unless *that* was an explicit focus of our attention as well. Fourth, modules' operations are *fast*. Fodor suggests that input analysis is fast because it is mandatory. The price of input systems' rapid, automatic responses, though, is that they confine themselves to a "stereotyped subset" of all of the possible options (1983, p. 64). Input systems' processing speed is largely a function of the fifth feature: these input systems are *informationally encapsulated*. We shall discuss this feature at greater length below.

The sixth feature of modules is that they have *shallow outputs*. Within their proprietary domains they have at their disposal only the most basic distinctions that are available on the basis of items' forms. So, in the linguistic domain, their outputs disclose syntactic structure but not the semantics of an utterance. In the visual domain, their outputs identify basic-level perceptual objects (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), which are at the most general conceptual level at which objects can be identified by their shapes (e.g., tables versus furniture). The seventh, eighth, and ninth characteristics of modules, respectively, are that they are

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associated with *fixed neural architectures*, that they show *particular, detailed patterns of failure*, and that their development "exhibits a *characteristic pace and sequencing*" (Fodor, 1983, p. 100).

Fodor maintains that the fifth of these features, informational encapsulation, is at the heart of modularity (1983, pp. 65–66; see also, Fodor, 2000, p. 63). Modules come equipped only with information about their proprietary domains. This amounts to an architectural constraint on their operations. *Ideally*, they generate their outputs on the basis of nothing more than the current stimuli that trigger their operation and the built-in information they possess pertaining to such stimuli and the domain in which they occur. These input systems' operations are not delayed by considerations of recollection or conceptual nuance or by concerns with coherence or integration with the rest of our knowledge. Such facets contribute to their speed, as do their restrictions on the number of "confirmation relations" that need to be estimated in the process of items' perceptual identifications, i.e., on the number of an item's features that must be confirmed in order for the input system to identify it (1983, p. 71).

This, however, is an ideal that Fodor qualifies from the outset. First, Fodor does not insist that perception overall is cognitively impenetrable, only that the work and products of input systems are (1983, p. 73). Second, he states that it is only "in certain respects" that the operations of input systems are uninfluenced by feedback from cognitive activity downstream (1983, p. 65). He concedes that psychology reveals some apparent counterexamples, such as the process of filling-in the blind spot (McCauley, 1993). In what he initially takes to be one of the most dramatic of these putative counterexamples (viz., the phoneme restoration effect), Fodor later suggests that the information fed back to early stages of processing within the linguistic input system may well come from *within* that input system itself (see note 6), and, therefore, this phenomenon may not count as a counterexample after all (1983, pp. 76–77).

Fodor does not offer any extended, *systematic* discussion of the principles that clarify the "certain respects" in which input systems' operations should *not* be cognitively penetrable on his account, but he does state that "the involvement of certain sorts of feedback in the operation of input systems would be incompatible with their modularity.... One or the other... will have to go" (1983, p. 66). Deciding which must go will hinge on the findings of relevant empirical research, and Fodor (2000, p. 115) stresses that even contemporary enthusiasts on behalf of far more liberal conceptions of modularity seem to recognize that the strongest evidence for informational encapsulation comes from the study of language and perception.

Probably the most compelling empirical evidence for the informational encapsulation of input systems is the *persistence* of some illusions. That is certainly the evidence Fodor cites most often. The point is not one about the mere existence of illusions but rather about our inability to shake some of them. He is concerned with cases in which *knowing that* some experience is illusory does not allay the illusory effect. So, for example, our knowledge that the two lines in the Müller-Lyer illusion are of equal length does not undermine the illusory impact of the directions of the arrowheads at their ends, even when we measure the lines' lengths (see Figure 1). Nor does *knowing why* the experience is illusory blunt this illusion's effect. For example, knowing that the effect can arise from construing the stimuli in terms of the relations of three-dimensional objects and their two-dimensional projections does not eliminate the illusion either. However well we understand what are going on with these stimuli, Fodor's point is that we are still unable to think away the illusory experiences they induce.

When he first discussed this sort of evidence, the visual illusions Fodor (1983, p. 66) cited were the Ames room, the phi phenomenon, and the Müller-Lyer (he also cited two linguistic illustrations). In virtually all subsequent discussions, however, Fodor returns repeatedly to the Müller-Lyer illusion—no doubt—because it is familiar, it is easily produced, it is reasonably well understood, and it provides a robust illustration for any of his readers, including devotees of the views of perception and scientific rationality that he is out to check. In reflecting on the persistence of the Müller-Lyer illusion, Fodor comments that it

> ...doesn't make it seem at all as though perception is, as it's often said to be, saturated with cognition through and through. On the contrary, it suggests just the reverse: that how the world looks can be peculiarly unaffected by how one knows it to be. I pause to emphasize that the Müller-Lyer is by no means atypical in this respect. (1984/1990b, p. 242)

Of course, on the accounts that Fodor opposes perception *is* supposed to be saturated with cognition through and through. They restrict no step in perceptual processing from the possible influence of what—at higher cognitive levels—we know about the world. On these accounts (such as Churchland's), perception is cognitively penetrable from top to bottom by the *theories* to which we subscribe. *That* is the place where these accounts of perception necessarily engage the philosophy of science. On these views, the transformations wrought by many of the greatest theoretical achievements in the history of science do not reduce to mere reinterpretations of stable, observable data. The theory impregnation of perception is so profound and extensive that Thomas Kuhn famously suggested in some of his most outspoken moments that, e.g., Aristotelian-Ptolemaic astronomers and Copernican astronomers "work in a different world" (1970, p. 135).

Churchland maintains that the pervasively speculative character of our knowledge of the empirical world is quite sufficient to discredit the notion of theory-neutral observation (even if changes in our theories have a less profound impact on how we perceive the world than Kuhn's comment suggests). The possibility of theory-neutral observation is undone, according to Churchland, because if empirical knowledge is *pervasively speculative* and such knowledge penetrates perception through and through, then *all* observation is theory-impregnated and is, at least, *subject to revision*. Presumably, since we have no way of knowing which observations we will never have an occasion to revise, such observational knowledge cannot serve as an unproblematic foundation for any other kind of knowledge.

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Churchland (1988/1989, pp. 255–256) outlines three consequences of adopting such a view. First, philosophical treatments of scientific rationality must develop more global accounts of decision making about competing scientific theories. Second, our observationally-based ontological commitments are simply one set of options among a vast number of possibilities all of which would square about as well with "our native sensory apparatus." And, third, as noted above, our observational knowledge is always revisable and, therefore, capable of improvement. Improved theories are all we need for improved observation.

For Churchland, then, the putative informational encapsulation of input systems cannot buy theory-neutral observation, because, first, even if these systems were informationally encapsulated, it would still not insure any theory-neutrality for observation; and, second, the empirical evidence suggests that they are not, in fact, encapsulated. We shall briefly review Churchland and Fodor's debates about the epistemological issue first before turning to an examination of the place of empirical considerations about visual illusions.

Churchland and Fodor's disagreements represent important differences about the connections between our conceptual commitments and the character of our experiences, about the semantics of natural language (and of observation terms, in particular), and about the basis of scientific progress. In their debate about the informational encapsulation of perceptual input systems, each tries to clarify the strength of the premises necessary for establishing the plausibility of the other's position. So, Fodor claims that to make the case for the theory dependence of observation, Churchland must defend the claims: (1) that perception engages *all* of the background knowledge a perceiver possesses, and (2) that, *in principle, all* descriptions of experience are sensitive to the perceiver's theoretical commitments (1988/1990a, pp. 243 and 262, respectively). Fodor argues that it is a "better bet" that only *some* centrally available information penetrates input systems (1990c, p. 200), as the critical issue is not whether the perceptual modules are absolutely isolated but simply whether they are "encapsulated *enough* to permit theory-neutral, observational resolution of scientific disputes" (1988/1990a, p. 255, italics added).

Although it is not obvious why Churchland must meet Fodor's first demand, in fact, he does not contest it—at least not directly. Fodor's second demand, however, is another matter. Two comments are in order. First, a point of clarification: Churchland's position does not rule out the possibility that a vast array of alternative theories might all be perfectly consistent with the same (or even a larger number of) observational claims. Second, Churchland *does* contest this second demand:

> We do not require . . . that *all* of the semantic properties of sentences or beliefs are determined by their theoretical context. So long as *some* of the semantic properties of any observation sentence are inevitably determined in that fashion, such sentences will be stuck with a significant burden of prejudicial theory. (1988/1989, pp. 272–273).[9]

Churchland, like Fodor, wants to claim the moderate, middle ground. Also like Fodor, he aims to shift the burden of evidence to his adversary: "To achieve a truly theory-neutral foundation for knowledge, Fodor needs a class of sentences or terms, *none* of whose semantic properties is dependent on theory" (1988/1989, p. 273). A problem for the demand Churchland makes here, though, is that the phrase 'theory-neutral' is ambiguous.

Churchland emphasizes that even if everything Fodor claims about modules is correct, this would not purchase theory-neutral observation. After all, Fodor himself sometimes describes the contents of perceptual modules as "hypotheses" and steadfastly insists that the processes they carry out are inferential (1988/1990a, pp. 249 and 244–245, respectively). Because we do not consciously utilize these endogenous hypotheses does not obviate, in the least, their *theoretical* status. Because all human beings come equipped with the *same* hypotheses does not secure neutrality or the "absence of any prejudice" but, instead, its "universality" (Churchland, 1988/1989, p. 259). Churchland pillories the suggestion that the inflexibility of perceptual input systems' contents, operations, and outputs obtains observation that is *a-theoretical*.

In his response, though, Fodor claims that he never intended to suggest this. He does not defend the a-theoretical character of the outputs of perceptual input systems (1988/1990a, p. 253). Observation can be theory-neutral in a different sense. Modules' deliverances take the shapes that they do on the basis of endogenous hypotheses (a) that virtually all human beings share, (b) that guarantee a fixity in these modules' outputs, but, most notably, (c) that are wholly *indifferent*, hence *neutral*, relative to the more sophisticated theories that we consciously and variously deploy in our more reflective verdicts about what we perceive. Fodor's aim is to specify "the psychological conditions under which differences among the theories that observers hold are *not* impediments to perceptual consensus among the observers" (1988/1990a, pp. 253–254). Fodor also explicitly recognizes (1984/1990b, p. 249, 1988/1990a, p. 254):

- that this consensus should not be confused with infallibility,
- that it will not help adjudicate every theoretical dispute in science (though, "almost all"), and
- that it certainly does include "bias."

Theory-neutral observation does not require a-theoretical observation. Thus, it is not clear whether Fodor need defend—as Churchland puts it—a "theory-neutral foundation for knowledge" in order to—as Fodor puts it— "permit theory-neutral, observational resolution of [almost all] scientific disputes," and, therefore, it begins to look as if Fodor may have successfully resisted Churchland's attempt to shift the burden.

But just after his comments acknowledging that modularity does not eliminate perceptual bias, Fodor seems to embrace *precisely* the stronger foundational program that Churchland describes that imposes the more exacting epistemological demands on theory-neutrality: "Contrary to Churchland, there seems no reason to doubt that

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this very restricted sort of bias might be compatible with more than enough perceptual neutrality to ensure for us a theory-neutral *foundation* for knowledge" (1988/1990a, p. 254, italics added). So, perhaps Fodor must shoulder some of the burden that Churchland aimed to foist upon him after all. If doing that requires the *complete* encapsulation of perceptual modules, then Fodor is quite clear that this is not in the cards, since not even "mad-dog nativists" like him hold so strong a view (1984/1990b, p. 248). It is not clear how Fodor would go about meeting those more exacting epistemological demands beyond insisting (rightly) that this debate mostly hangs on the way the empirical evidence about perception turns out (see Fodor, 1983, p. 66, 1988/1990a, p. 255). More particularly, the debate would certainly hang on the way the evidence turns out about the cognitive penetrability of the features of the visual input system responsible for humans' susceptibility to his favorite persisting illusion, viz., the Müller-Lyer.

Before pressing ahead, we should underscore another qualification Fodor introduces about informational encapsulation. He unequivocally questions only the *synchronic* penetration of the module that "mediates visual form perception" and informs the Müller-Lyer illusion (1984/1990b, p. 247). Nothing that we can think or think about, including the fact that it is an illusion, can *here and now* undue the illusory effects of the Müller-Lyer stimuli. From a synchronic perspective, it seems to be cognitively impenetrable. Fodor, however, does not absolutely rule out its *diachronic* penetration. He explicitly concedes the *possibility* that "experience and training" with some stimuli over time might alter the access to our background knowledge of perceptual input systems (1984/1990b, pp. 247–248).

Although they would not construe their findings in those terms, ecological realists have provided ample evidence that even quite limited experience with many standard illusions, arising from drawings in two dimensions, can readily dispel those drawings' illusory effects. Inspired by the work of James Gibson (1966, 1979), ecological realists conceive of perception as an ongoing process involving a moving organism involved in active exploration of its environment. (For ecological realists virtually all perception is diachronic!) And they have supplied evidence that the perception of visual illusions is *often* what Fodor would seem to have to describe as diachronically penetrable. Experimental research has demonstrated that subjects who are able to view various visual illusions from glancing angles are frequently able to dispel the illusions and that subjects who are simply able to circle around some two-dimensional, illusory figures can discern aspects of shape correctly (Kennedy & Portal, 1990).

Still, these observations occasion three comments in Fodor's defense. First, Fodor (see below) acknowledges that at least some ecological considerations may pose exceptions to the diachronic encapsulation of modules and of the visual input system, in particular. Second, and more crucial for our purposes, these researchers have not produced such findings for the Müller-Lyer illusion. It does not seem to be so readily dispelled—at least not by any of the measures that Kennedy and Portal (1990) employ with the illusory figures they study. It, in short, continues to prove a *persisting* illusion. And third, Fodor explicitly grants that some modules,

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e.g., those that pertain to our linguistic abilities, *are* diachronically penetrable. As we noted earlier, Fodor suspects that which ones are, and the ways in which they are, are also specified endogenously. The linguistic module, for example, must be penetrable on some fronts, since children who grow up where everyone else speaks Norwegian themselves speak Norwegian, whereas others—similarly equipped—who grow up where everyone else speaks Japanese reliably end up as speakers of Japanese.

Fodor does not think that such considerations pose serious problems, however, since he knows of no reasons to think that on the diachronic front "just any old learning or experience can affect the way you see" and the way you see the Müller-Lyer illusion, in particular (1984/1990b, p. 248). Diachronic penetration of perceptual modules is benign so long as it allows "perceptual consensus to survive the effects of the kinds of differences in learning histories that observers actually exhibit" (1988/1990a, p. 257). Fodor admits that we do not know for sure whether it does, since the data are not in, but if diachronic encapsulation is "pervasive" (1988/1990a, p. 258), then we will be some way toward providing an account of the theoretical neutrality of observation. Fodor's suggestion (1988/1990a, p. 254) that theory-neutral observation promises to help adjudicate "almost all" theoretical disputes in science suggests that—the experimental findings of the ecological realists to the contrary notwithstanding—he thinks that diachronic penetration of input systems is rare.

Churchland holds that this question of *diachronic* penetrability is pivotal, since no one championing the theory-impregnation of perception ever held that anyone's perception changed *instantly* as the direct result of adopting some new belief. Human beings must *learn* to see in new ways and learning takes time (though the ecological realists' findings suggest that with at least some two dimensional illusory figures, it may not take either much learning or much time!). Still, Churchland argues that the facts are overwhelmingly on his side. It is diachronic penetrability rather than diachronic encapsulation that predominates.

Churchland notes the prominence Fodor accords to the persistence of the Müller-Lyer illusion and speculates about the possibility that extensive experience in some possible environments might render humans immune to its effects (1988/1989, pp. 261–262). Instead of reviewing available evidence about the Müller-Lyer, though, Churchland discusses various ambiguous figures as well as studies on inverting lenses that make the world appear upside down. Fodor replies that our abilities to orchestrate our experiences of ambiguous figures depend not on changes in our beliefs but rather on changes in our fixation points and, therefore, they constitute no evidence for penetrability (1988/1990a, pp. 255–256).

The studies of inverting lenses are famous, however, precisely for what manifestly seems to be their demonstration of diachronic penetrability. Subjects wearing the inverting lenses, after an initial period of disorientation, adjust readily within a couple of weeks and basically experience the visible world normally. Moreover, they experience the same sequence of stages when they shed the lenses as well. These cases seem quintessential illustrations of diachronic penetrability, and, Fodor concedes,

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so they are; but, he adds, they constitute an *exception* we should expect (1988/1990a, pp. 258–259). These studies involve subjects having to recalibrate the mappings between their visual perception and their motor systems. That, Fodor argues, is precisely the sort of case that we *should expect* to be penetrable on ecological grounds. Over the course of our lifetimes our bodies change a great deal in size and shape. Those changes require adjustments, albeit less extreme, of the same sort that the inverting lenses demand. It should come as no surprise that subjects' cognitive systems are capable of making these adjustments, since they are making (less extreme) corrections of the same types for much of those subjects' lives.

Although the list of qualifications and exceptions concerning the informational encapsulation of input systems grows (e.g., see Pylyshyn, 1999, p. 360), Fodor's rationales in most cases make perfectly good sense. This growing list of concessions, however, makes the critic wish for a comprehensive catalog—up front—of the pertinent principles delineating such exceptions, if for no other reason than to save time. If critics such as Churchland, without such a catalog, are disinclined to see that list of concessions as compromises in spirit, if not in letter (and nothing about Fodor's rhetoric would invite them to see those concessions that way), then, presumably, the one case that *would* constitute a formidable counterexample to Fodor's position would be to provide empirical findings that suggest that his prized illustration, the Müller-Lyer illusion, is, as Churchland speculates, at least diachronically penetrable. We turn in the next section to studies that suggest just this, at least across the course of standard cognitive development. In short, some of the data are (actually, were) in.

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3. Cross-Cultural Data Indicate that the Müller-Lyer Illusion is Diachronically Penetrable—at Least During the Course of Cognitive Development

Corroborating the findings of W. H. R. Rivers' (1901, 1905) pioneering work in the early twentieth century on visual illusions, Segall, Campbell, and Herskovits (1966) performed one of the most extensive, rigorously controlled, cross-cultural experimental projects in the history of collaboration between psychologists and anthropologists. The project equipped ethnographers with detailed instructions, experimental protocols, and uniform stimuli for testing five different visual illusions, including the Müller-Lyer, in a variety of small-scale societies. For our purposes, their findings show that Fodor's favorite example of cognitive impenetrability is diachronically penetrable after all. They show that individuals who grow up in *some* sorts of visual environments during their first twenty years of life are not susceptible to the illusion. Furthermore, these results, along with those from many other studies of typical "Western" subjects, show that children are usually not less susceptible to the Müller-Lyer illusion compared with adults (as Fodor, 1984/1990b, p. 241, maintains), but *more* susceptible.

Table 1. Details for Samples

Group	Country/City	Sample Size
Ankole Adults/Kids	Uganda	131/93
Toro Adults/Kids	Uganda	49/37
Suku Adults/Kids	Congo Republic	40/21
Songe Adults/Kids	Congo Republic	45/44
Fang Adults/Kids	Gabon Republic	42/43
Bete Adults/Kids	Ivory Coast	38/37
Ijaw Adults/Kids	Nigeria	47/37
Zulu Adults/Kids	South Africa	21/14
San Adults	Kalahari Desert	36
S.A. European Adults	Johannesburg	36
S. A. Miners	South Africa	60
Senegal Adults/Kids	Senegal	74/51
Dahomey Kids	Guinea Coast	40
Hanunoo Adults/Kids	Philippines	37/12
Evanston Adults/Kids	U.S., Illinois	111/77
Bassari Adults/Kids	Eastern Senegal	50/50
Yuendumu	Central Australia	52

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In the Müller-Lyer illusion (Figure 1), ‘‘Western’’ subjects typically perceive that the horizontal line segment marked *b* is longer than the horizontal line segment marked *a*, when in fact *a* and *b* are the same length. By varying the lengths of *a* and *b* over a series of presentations and asking subjects which of the two is longer, researchers can estimate the magnitude of the visual illusion for each by estimating the length difference at which a subject perceives the line segments as equal in length.

Table 1 lists the groups’ names, their locations, and the sample sizes in the Segall, Campbell, and Herskovits (1966) study.[10] These 17 societies included 11 groups of African agriculturalists (some of whom also rely on foraging and pastoralism), one group of African foragers (San), one group of Australian Aboriginal foragers (Yuendumu), one group of Philippino horticulturalists (Hanunóo), one group of South African goldmine-laborers (which we label ‘‘S.A. Miners’’), and two groups of ‘‘Westerners’’ (South Africans of European descent and Americans). From 12 of these 17 societies, data were gathered from both adults (split equally between males and females, ages 18–45) and children (ages 5–11). No child data were collected among the S.A. Miners, the San, the Yuendumu, or the S.A. Europeans. No adult data were collected from the Dohomey.

Figure 2 summarizes the results for the Müller-Lyer illusion from the 17 societies. In Figure 2, the left-hand vertical axis gives the ‘‘point of subjective equality’’ (PSE). PSE is a measure of the strength of the illusion. It represents what *percent* longer *a* must be than *b* before people perceive them as equal (until there is a 50-50 chance that people from that group will choose either *a* or *b*). The white and black bars (for kids and adults, respectively) show the mean PSE for each group. The right-hand vertical axis gives the difference between the PSE of the adults and children for each group and refers to the scatter of data points above the vertical bars. The names of the groups span the x-axis.

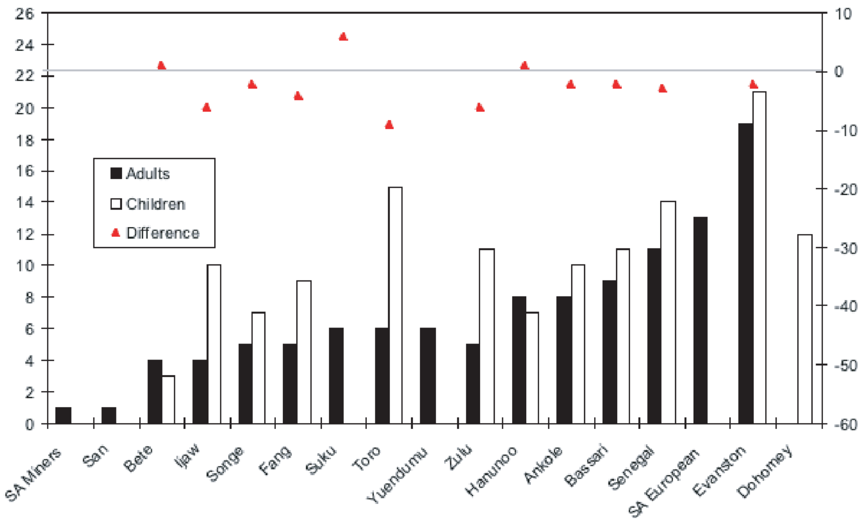

Figure 2 Müller-Lyer Results from Segall et al.'s (1966) Cross-cultural Project. PSE is the percentage that segment *a* must be longer than *b* before individuals perceive them as equal.

The results for the Müller-Lyer stimuli show substantial differences among these social groups in their susceptibility to the illusion. American adults in Evanston, Illinois are the most susceptible. On average, these adults require that segment *a* be about a fifth longer than *b* before they perceive them as equal in length (PSE = 19%). At the other end of the "susceptibility spectrum," hunter-gathers from the Kalahari Desert are virtually immune to the "illusion." (They probably would not even recognize it as an illusion.) This population, on average, requires that segment *a* be only one percent longer than segment *b* before seeing them as equal (PSE = 1%). Looking across Figure 2, while there is significant variation across the range of social groups, there is a distinct jump between the rest of the societies and Evanston. Using *t*-tests pairing Evanston against all other groups, and adjusting for repeated comparisons, Segall et al. (1966, p. 156) show that all are significantly different at the 0.05 level.

The results from the children (ages 5–11) reveal a pattern similar to that observed for the adults. PSE scores range from over 20% among children in Evanston to 3% among Bete kids and 0% among the Suku children. The PSE scores for children correlate with their adult counterparts, $r = 0.81$, indicating that *most of the cross-cultural effect is in place by age eleven*. Moreover, the amount of cross-group variation drops from a standard deviation (in group PSE's) of 5.5 among children to 4.5 for adults. In other words, cross-cultural variation is *greater* among children than adults. So, on balance, adolescence seems to reduce this cross-cultural variation. Although it may be true that not "just any old learning or experience can affect the way you see" (Fodor, 1984/1990b, p. 248), it does appear that a variety

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of different arrangements can have an impact on how children see the Müller-Lyer stimuli.

Developmentally, the PSE scores show a fairly robust pattern: Adults are typically *less* susceptible to the illusion than children. This is illustrated by the scatter of triangles on the upper portion of Figure 2. With three exceptions, the adults' scores are less than those of the children from their society—which is represented in Figure 2 by the triangles below the dotted zero-line. Of the three exceptions, only one is much above zero. The absence of a bar for Suku children does *not* indicate missing data. Suku children were, on average, not susceptible to the illusion, providing the lowest score of all the groups. Finally, note that while children were usually equal to or greater than adults *from their social group* in susceptibility, this pattern does not hold if we compare children and adults from different societies. Many children from one society are less susceptible to the illusion than adults from other societies are.

These findings are consistent with more detailed developmental data from American populations showing that adults are less susceptible to the illusion than children (Walters, 1942; Wohlwill, 1960). Several studies show that susceptibility to the Müller-Lyer illusion generally *decreases* from ages 5 to 12 among American subjects, reaching its lifetime low at the onset of adolescence, and then increasing from 12 to 20. The decrease from 5 to 12 is larger than the subsequent increase in susceptibility, leaving these American adults less susceptible to the illusion than five-year-olds. Figure 3 shows this developmental trajectory for the Müller-Lyer illusion using data from Wapner and Werner (1957).[11] Available research suggests that after 20, susceptibility to this illusion does not change again until old age (Porac & Coren, 1981; Wapner, Werner, & Comalli, 1960).

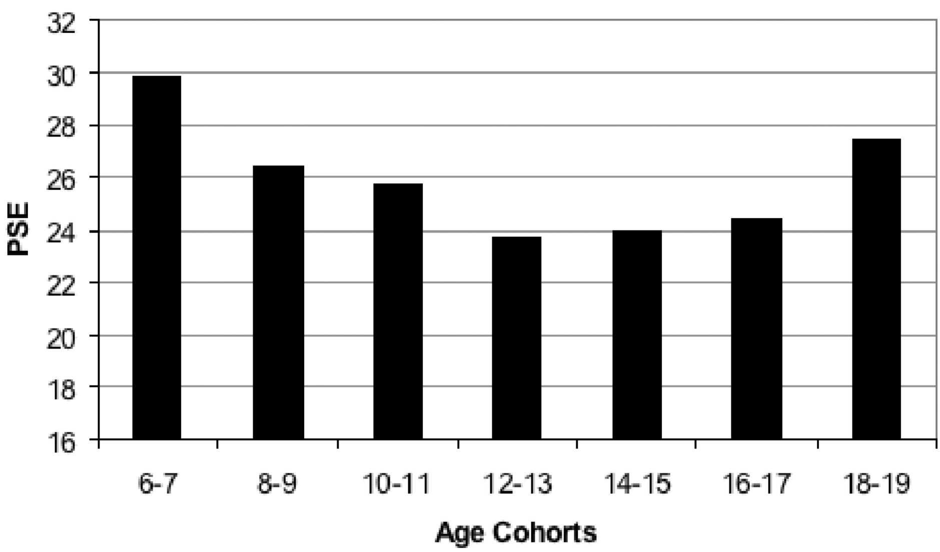

Figure 3 Developmental Data for U.S. Subjects Using the Müller-Lyer Illusion. Data are from Wapner and Werner (1957: Appendix 15).

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Explanations for the observed cultural variation in people's susceptibility to visual illusions center around the (distinctly non-Fodorian) notion that the human visual processing system will somehow adapt to the local visual environment by building up biases that tend to produce useful inferences in that environment. Various hypotheses exist about what the pertinent variables are, and scientists have tested these hypotheses (Berry, 1968, 1971; Stewart, 1973). Specifically, with regard to the Müller-Lyer illusion, Segall et al. (1966) examined the "carpentered environments" hypothesis. This hypothesis suggests that exposure to rooms, houses, buildings, and furniture with sharp, carpentered, right-angled corners causes the visual system to "assume" that certain angles (projected on the retina in 2-D) actually indicate depth. This visual bias leads viewers of the Müller-Lyer illusion to see the lines as having different lengths because the visual system assumes the angles are right angles (and infers the corresponding depths). Alternatively, instead of carpentered environments, it may be that the exposure to perspective in art (which creates the illusion of a 3-D space) leads to the biases that create the Müller-Lyer illusion. The complete answer may involve both of these and more. Our present case, however, does not turn on what specific hypotheses might explain the cultural variation.

The combination of the developmental and cross-cultural data suggest: (1) that whatever causes the members of these different societies to vary in their susceptibility to the illusion likely has its effects between birth and age twenty, but not afterwards; (2) that the cause or causes have much of their effect before age 11, otherwise children in the cross-cultural sample would not mirror the adult pattern; and (3) that explanations in terms of variables like experience in a carpentered environment may be misleading. It appears that what matters is not experience in carpentered environments (or whatever the relevant variable is), but rather experience with the relevant variable *before* age 20.

This pertains to criticisms that the carpentered environments hypothesis fails, because males and females in many of these societies have experienced substantially different amounts of contact with carpentered environments. For example, in the 1960s many more males than females in South Africa sought wage labor in cities and in the mines, yet males and females consistently show little or no difference in their susceptibility to the illusion. That finding supports rather than contradicts the developmentally informed version of the carpentered environments hypothesis, since these females and males lived in virtually identical visual environments between birth and adolescence. Differences in the experiences of males and females after age 20 seem to have little impact, thus, it should come as no surprise that the findings for males and females are similar.

For our purposes here the crucial points are, contrary to Fodor's proposals, that Segall et al.'s (1966) findings demonstrate considerable cultural variation with respect to humans' susceptibility to the Müller-Lyer illusion and that it looks as though, depending upon their visual experiences during childhood, some people are not susceptible to the illusion at all.

Concerns about these empirical findings might focus on whether the field researchers employed similar methods in their gathering of data across the various

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societies. Several features of this research should mitigate such worries. First, an interdisciplinary team of a respected anthropologists (with experience in small-scale societies) and psychologists, well known for their methodological sophistication, designed the project. Second, rather than the experimenter "dropping in" for a few weeks and running a quick experiment (without knowing the people, culture, or language), the project utilized experienced ethnographers who were experts on the study populations. Third, the lead investigators took a variety of steps to introduce controls and avoid methodological inconsistencies. These included:

1. The ethnographers were supplied with a 70-page "how-to" instruction booklet printed on washable paper. The book contained the experimental stimuli, detailed instructions on administering the experiments, sampling guidelines, and a set of questions about the environment and the visual world of the society.
2. To reduce ambiguities in the translation of the written instructions, the line segments representing the arrowheads and tails were separated from the segments (*a* and *b* in Figure 1) whose lengths were in question. Further, these line segments were colored red, while the arrowheads and tails were black. Focal red and black were chosen because these colors are distinguished linguistically in all the societies studied. Separating the line segments avoids any confusion about whether the length judgment might include the arrowheads and tails, and using color allowed the experimenter to unambiguously refer to the line segment under investigation. Adding color and separating the line segments slightly reduces the potency of the illusion, which should only act to *reduce* the magnitude of the differences between groups.[12]
3. The investigators interviewed the ethnographers at the end and recorded any systematic methodological variations. Few were found.

Supporting the effectiveness of these safeguards, several patterns among the empirical findings suggest that uncontrolled methodological variation did not contaminate these results. For example, many of the experiments with African agriculturalists produced similar results, all of which contrast with the results from the subjects from the United States. If variation in the findings was principally a product of methodological variation introduced by experimenters or translations, then these African agricultural groups (which are linguistically diverse) should vary as much from one another as they do from the "Westerners."

Finally, concerning their general conclusion about the cross-cultural variation in Müller-Lyer susceptibility, Segall, Campbell, and Herskovits' work replicates Rivers' earlier findings. Rivers did all of his own studies (one experimenter, one protocol), and he did them with Melanesian populations, which are not represented among the Segall et al. (1966) groups. This adds external validity to the Segall et al. (1966) findings (a) by replicating the results in a set of experiments all done by the same experimenter and (b) by showing the same kind of variation appears using an entirely unrelated population.

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4. Conclusions

These findings pose problems (1) for Fodor's (and Pylyshyn's) appeals to the persistence of the Müller-Lyer illusion as evidence for the informational encapsulation of the visual input system, (2) for their contention that the features of the visual input system responsible for humans' susceptibility to the Müller-Lyer illusion are overwhelmingly endogenous, and (3) for Fodor's proposal for a theory-neutral, observational foundation for scientific knowledge. In what follows we discuss the first two problems conjointly and then take up the third. We end by suggesting that all of this at least hints at the possibility of arrangements among adult observers that, for different reasons, neither Fodor nor Churchland nor the ecological realists will find thoroughly congenial.

Concerning the first two problems, Segall et al.'s (1966) findings indicate that the verdict about children's susceptibilities to the Müller-Lyer illusion is not a simple one and that it certainly is not the one that Fodor presumes (e.g., 1984/1990b, p. 241). Only 3 of the 12 cultures, for which Segall et al. provide data for both, conform to Fodor's claim that children are less susceptible than adults. On the other hand, in one of the three cases where children were less susceptible, viz., the Suku, the findings present what looks like an even more troublesome problem for Fodor's larger position concerning the (innately specified) informational encapsulation of modules, since Suku children do not seem susceptible to the Müller-Lyer illusion *at all*. It seems unlikely that complete imperviousness to the illusion is what Fodor has in mind when he maintains that children are "less susceptible" than adults. Still, perhaps even the finding with the Suku children falls within the compass of what Fodor envisions about the range of variation that is possible among children. So, by itself, this finding does not undermine his appeal to the persistence of the Müller-Lyer illusion as evidence for the informational encapsulation of the visual input system.

Conjoined, however, with the fact that San adults and the mine workers in South Africa also manifested virtually no susceptibility to the Müller-Lyer illusion, the findings about the Suku children begin to appear less like a developmental outlier and more like one of a range of possibilities, in which humans' physical and cultural circumstances shape (not just trigger) visual input systems in ways that are quite unlike what Fodor maintains and that can lead to a *variety* of different configurations across cultures and (therefore) between individuals. Persisting susceptibility to the illusory effect of the Müller-Lyer stimuli in adults almost certainly hangs on *culturally contingent* conditions during (roughly) the first 20 years of observers' lives. There is *no* reason to think that the variability in the findings of the studies on which we have reported turns on genetic differences.

How encapsulated a module is seems to depend on an organism's stage of life. Specifically, at some time during the first 20 years of humans' lives it appears that their *visual input systems exhibit diachronic cognitive penetrability*, at least in the second sense (represented by item (b), in §1). What the visual input system delivers to the central cognitive processors in the adult brain pertaining to the Müller-Lyer

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stimuli seems to rest as much on how and where the individual grew up as on any innate specification or pre-programming. This feature of the visual input system does not seem to be informationally encapsulated in quite the way that Fodor has described. More precisely, it is not informationally encapsulated in such a way as to reliably render every human being susceptible to the Müller-Lyer illusion.

How do these considerations bear on Fodor's case for a theory-neutral observational foundation for scientific knowledge? Fodor stresses that diachronic penetration of perceptual modules poses no problem for an account of scientific objectivity grounded in theory-neutral observation so long as it allows "perceptual consensus to survive the effects of the kinds of differences created by the learning histories that observers actually exhibit" (1988/1990a, p. 257). What Segall et al. (1966) indicate, however, is that the learning histories that observers actually exhibit result in deliverances from the visual input system that are not only not the same in every human mind or even the same in every adult human mind but, in fact, leave some people immune to the Müller-Lyer illusion—i.e., to *the* illusion to which Fodor has most steadfastly clung as evidence for the possibility of such a perceptual consensus.

What Fodor has consistently taken, then, as the single most uncontroversial piece of empirical evidence for the informational encapsulation of the visual input system (and, therefore, for the possibility of theory-neutral observation) is suspect. Such an outcome challenges Fodor's program for developing a viable account of scientific agreement on the basis of theory-neutral observation at least to the extent that he:

(a) cites the persistence of the Müller-Lyer illusion as his showcase argument on behalf of informational encapsulation and, thereby, on behalf of the possibility of theory-neutral observation;
(b) stresses that—unlike inverting lenses—the Müller-Lyer is *not* an exception to his general argument concerning the persistence of illusions;
(c) suggests that the informational encapsulation of input systems responsible for the illusory effects of the Müller-Lyer stimuli is innately specified and, therefore, virtually universal;
(d) maintains that even if informational encapsulation were "pervasive," we would still only be within "hailing distance of a naturalistic account of how theory-neutral observation is possible" (1988/1990a, p. 258); and
(e) presumes that any observational foundation for scientific knowledge relies upon a consensus at least about such things as how the stimuli that produce (allegedly) persistent illusions appear.

What the research of Segall et al. (1966) shows, even with respect to Fodor and Pylyshyn's favorite example, is that informational encapsulation is not comprehensively specified in the human genome, that it is not pervasive, and that there is no consensus about the pertinent stimuli among human observers. For those who experience it, the illusion may persist, but susceptibility to the Müller-Lyer illusion is neither uniform nor universal. Moreover, a plausible argument can be made that through most of our species' history *most* human beings were probably *not* susceptible to the illusion. Although Suku children, San adults, and a sample of South African mine workers

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from the early 1960s are the only groups in the study that manifest substantial imperviousness to the Müller-Lyer illusion, we suspect that they are not the only human beings in history who would have. For most of human history, people were raised in visual environments closer to those inhabited by people like the Suku and the San than to those characteristic of Evanston, Illinois. In addition, we have no guarantees about the predominant visual environments of human beings in the distant future.

Note that nothing about any of the findings we have discussed establishes the *synchronic* cognitive penetrability of the Müller-Lyer stimuli.[13] Nor do the Segall et al. (1966) findings provide evidence that *adults*' visual input systems are *diachronically* penetrable. They suggest that it is only during a critical developmental stage that human beings' susceptibility to the Müller-Lyer illusion varies considerably and that that variation substantially depends on *cultural* variables. At the same time, Wapner and Werner's (1957) findings suggest that such variation may follow a characteristic developmental pattern (see Figure 3). Although these findings reveal abundant variation on some fronts, the developmental changes are not random and the culturally specific outcomes are neither random nor uniform.

With more than a touch of sarcasm, though, Granny might well reply at this point, "Sound familiar?" Careful scrutiny of this analysis would seem to indicate that the visual input system is *quite like the linguistic input system*—as Fodor has maintained all along. After all, the ready acquisition of natural languages also occurs only during a critical developmental stage. Human beings' susceptibility to linguistic "illusions," such as native Japanese speakers' inability to distinguish the /r/ and /l/ sounds of English (Logan, Lively, & Pisoni, 1991) varies considerably too and that variation also substantially depends on cultural variables. Moreover, by now, dozens of studies have traced characteristic developmental patterns in the acquisition of phonology and syntax. Although these findings reveal abundant variation on some fronts, with language too the developmental changes are not random and the culturally specific outcomes are neither random nor uniform.

Some aspects of visual observation—at least the deliverances of the visual input system responsible for adults' susceptibility or immunity to the Müller-Lyer illusion—*may* be quite like the "observation" of language. But if so, that is not unequivocally happy news for *any* of the positions we have canvassed. Churchland will not care for the suggestion that the plasticity of visual perception in adults may be irredeemably constrained on some fronts. Conversely, neither ecological realists nor Fodor will be pleased by the suggestion that the influence of what look to be culturally contingent factors can result in adults who cannot help seeing at least some things differently.

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Notes

[1] So, e.g., Daniel Dennett's *Consciousness Explained* (1991) includes an appendix for scientists as well as one for philosophers.

[2] See, e.g., papers citing empirical findings that seem to pose problems for Dennett's (1991) proposals about the character of consciousness such as Churchland and Ramachandran (1993) and McCauley (1993).

[3] Although this paper and the subsequent exchange with Paul Churchland that we discuss appeared in various issues of *Philosophy of Science*, we shall cite the page numbers for passages from these various papers in what we presume are more readily available versions in Fodor's *A Theory of Content and Other Essays* (1990) and in Churchland's *A Neurocomputational Perspective* (1989).

[4] Thus it is not too surprising that his pioneering attention to mental modules' specifications notwithstanding, Fodor (2000) has proven unsympathetic to the recent proliferation of modular analyses. To him it seems modularity run amok.

[5] It is important to note, however, that Fodorian modules can have access to information other than that provided by their inputs. Fodor allows that input systems may contain information about their proprietary domain from the outset and that top-down processing *within* a module on the basis of such information can occur (1983, pp. 76–77).

[6] See, e.g., the brief discussion in the next section concerning (Churchland's citation of) the famous studies with inverting lenses.

[7] See, e.g., the brief discussion in the next section concerning relevant research by ecological realists inspired by Gibson's approach to perception.

[8] Again, see the brief discussion of the inverting lens experiments in the next section.

[9] One way to handle this apparent impasse might be to note that Fodor and Churchland's comments invoke items (viz., descriptions as opposed to the semantic properties of expressions) at different analytical grains. (Thanks to Charles Nussbaum for bringing this point to our attention.)

[10] In Table 1 we listed the locations and countries given by Segall et al. (1966), and have not updated the names of the countries.

[11] Wapner and Werner (1957) used stimuli that differed slightly from those Segall et al. (1966) used, and the PSE values indicate a stronger effect.

[12] Segall et al. (1966, ch. 7) discuss how variations in the details of the Müller-Lyer stimuli influence the magnitude of the illusory effect. The modifications in question are not a problem for interpreting the results, because exactly the same stimuli were used in every society, including Evanston.

[13] As we have seen, though, Churchland insists that no one ever meant to suggest that this illusion or any others were synchronically penetrable.

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