

Adaptive Complexity and Phenomenal Consciousness*

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Arguments about the evolutionary function of phenomenal consciousness are beset by the problem of epiphenomenalism. For if it is not clear whether phenomenal consciousness has a causal role, then it is difficult to begin an argument for the evolutionary role of phenomenal consciousness. We argue that complexity arguments offer a way around this problem. According to evolutionary biology, the structural complexity of a given organ can provide evidence that the organ is an adaptation, even if nothing is known about the causal role of the organ. Evidence from cognitive neuropsychology suggests that phenomenal consciousness is structurally complex in the relevant way, and this provides prima facie evidence that phenomenal consciousness is an adaptation. Furthermore, we argue that the complexity of phenomenal consciousness might also provide clues about the causal role of phenomenal consciousness.

1. Introduction. In a recent paper, Owen Flanagan and Thomas Polger propose that explaining why consciousness evolved is “the hardest problem in consciousness studies.” (1995, 313) Not only are there “no credible explanations” of the evolution of consciousness (1995, 321), the possibility of zombies (i.e., organisms that are behaviorally indistinguishable from us but lack consciousness) raises a serious question about the adaptive sig-

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nificance of phenomenal consciousness. (1995) In this paper, we take up Flanagan and Polger's challenge to provide a more credible argument for the claim that phenomenal consciousness is an adaptation.

Recent discussions of the evolution of consciousness have focused on two interrelated issues. The first set of issues concerns how and why consciousness emerged in the course of evolution. For example, did consciousness arise through natural selection, or did it evolve as a free rider? These questions concern the *evolutionary* function of consciousness. The difficulty of specifying the evolutionary function of consciousness is exacerbated by a quite different issue, the epiphenomenalist worry that phenomenal consciousness doesn't play any significant *causal role* function in shaping human action. (Block 1995) The combined problem of characterizing both the evolutionary and causal role function of consciousness presents an extremely difficult challenge to any argument that phenomenal consciousness is an adaptation. Since we are not sure whether phenomenal consciousness plays any significant causal role in human thought, it has been hard to address the issue of how and why phenomenal consciousness evolved.

We offer an approach that circumvents these difficulties. We will argue that there is reason to think that phenomenal consciousness is an adaptation even in the absence of any characterization of the evolutionary or causal role function of phenomenal consciousness. According to contemporary evolutionary biology, it is reasonable to assume that complex biological structures are adaptations—even if we do not know precisely how the organ functions or how it evolved. The complexity of phenomenal consciousness thus provides an argument that phenomenal consciousness is an adaptation. By providing evidence that consciousness is an adaptation, the complexity argument can simultaneously undercut the epiphenomenalist suspicion. For if consciousness is an adaptation, it must have some causal effect on fitness. Indeed, if we can establish that phenomenal consciousness is an adaptation, we think that this might provide a basis for developing a partial account of the evolutionary and causal role functions of phenomenal consciousness. Before we can make our case, we need to briefly review recent debates over the function of phenomenal consciousness.

2. Epiphenomenalism and Causal Role Function. It is tempting to begin the search for the evolutionary function of consciousness by establishing the causal role function of consciousness. However, epiphenomenalism poses a familiar problem for any attempt to establish the causal role of consciousness. For any proposed function of consciousness, it's easy to construct a story in which consciousness plays no causal role but rather is

merely epiphenomenal. As Flanagan puts it, the “epiphenomenalist suspicion is extraordinarily hard to dispel.” (1992, 133)

In the last decade, several theorists have tried to discredit epiphenomenalism by appealing to empirical findings on psychopathologies. These psychopathology arguments maintain that epiphenomenalism is undermined by evidence that apparent deficits in phenomenal consciousness are correlated with apparent cognitive and behavioral deficits. This kind of argument has been suggested by several prominent theorists (e.g., Marcel 1986, Van Gulick 1989, Flanagan 1992, and Searle 1992). Perhaps the most detailed version of the argument is offered by Flanagan (1992). He writes:

There are all sorts of cases of neurological deficits linked with deficits in subjective consciousness, and in many of these cases the incapacitation of subjective consciousness seems to explain some further incapacity Blindsighted patients never initiate activity toward the blindfield because they lack subjective awareness of things in that field. Prosopagnosiacs don't consciously recognize familiar faces. Thus they don't rush to greet long-lost friends, even though their hearts go pitter-patter when they see them. (1992, 145)

Flanagan maintains that these correlations between subjective deficits and cognitive deficits help to show the function of consciousness. “The inference to the best explanation is that conscious awareness of the environment facilitates semantic comprehension and adaptive motor control actions in creatures like us.” (1992, 141–142)

Although Flanagan's argument is enticing, Block (1995) maintains that psychopathology arguments conflate two distinct notions of consciousness, phenomenal consciousness and access consciousness. Phenomenal consciousness, according to Block, is experience: “P-consciousness properties include the experiential properties of sensations, feelings, and perceptions, but I would also include thoughts, desires, and emotions.” (Block 1995, 230) Access consciousness, on Block's view, is characterized by information-processing features:

A state is access conscious (A-conscious) if, in virtue of one's having the state, a representation of its content is (1) inferentially promiscuous (Stich 1978), that is, poised for use as a premise in reasoning, (2) poised for rational control of action, and (3) poised for rational control of speech. (1995, 231)

This gloss places access consciousness comfortably within the rich tradition of information-processing explanations in cognitive science. “A perceptual state is access-conscious roughly speaking if its content . . . is processed via that information processing function . . . whereby it can be used

to control reasoning and behavior.” (Block 1995, 229) Block’s argument, then, is that although blindsight patients lack phenomenal consciousness of the relevant stimulus, say a cup of water, the fact that they don’t reach for the cup of water might also be explained by their lack of *access consciousness*.

Block maintains that access consciousness and phenomenal consciousness must be distinguished conceptually and that there may even be empirical cases in which access consciousness is present without phenomenal consciousness. To illustrate this, Block suggests that it is at least conceptually possible that a blindsight patient could learn to rely on information in his blindfield to initiate behavior, and in this case, the person would have access consciousness of visual stimuli without phenomenal consciousness. Block calls this “superblindsight” and suggests that Nicholas Humphrey’s monkey Helen might be an actual case of superblindsight. Humphrey agrees:

Helen, several years after removal of the visual cortex, developed a virtually normal capacity for ambient spatial vision, such that she could move around under visual guidance just like any other monkey. This was certainly unprompted, and in that respect ‘super’ blindsight. (Humphrey 1995, 257)

Weiskrantz also maintains that the case of Helen indicates that “under pressure the visual capacity may recover some of its sensitivity and ability to respond without prompting.” (Weiskrantz 1997, 178) As a result, there is some reason to think that it’s possible to have access consciousness of sensory input without having phenomenal consciousness of the input.

Of course, Humphrey’s Helen certainly does not behave like a normally sighted monkey. In particular, Helen seems incapable of categorizing objects (e.g., food/non-food) on the basis of visual information. (Humphrey 1974, 245) It remains to be seen whether the psychopathology argument against epiphenomenalism might be redeployed to argue that, while phenomenal consciousness may not be necessary for access consciousness, it’s necessary for something else, e.g., categorization of sensory input. One reason to be skeptical of this move is that it seems that the categorization of sensory input can happen without phenomenal consciousness. For example, in unilateral neglect, subjects behave as though half of their visual field is absent, yet they seem to exhibit implicit understanding of the visual information. In one widely cited study, researchers showed a subject two pictures of a house, one with flames coming out of the left side of the house. The subject claimed that the two houses were identical, but when asked to choose which house she’d rather live in, she reliably picked the one that was not on fire. (Marshall and Halligan 1988) In this case, then,

it seems that the subject was making the proper categorization of a visual input without being phenomenally conscious of it.

As these examples suggest, the burgeoning literature on psychopathologies presents us with an extremely complex set of correlations between deficits in phenomenal consciousness and deficits in information processing capacities. And it is quite unclear whether there is *any* general information-processing function for which phenomenal consciousness is necessary. If this is right, then the epiphenomenalist threat continues to pose a problem for the argument from psychopathology.

Thus, if Block's influential critique of the psychopathology argument is right, then epiphenomenalism still poses a serious difficulty for the attempt to establish the causal role function of consciousness. However, we will argue that the evidence from psychopathologies can serve a rather different kind of argument against epiphenomenalism. To develop this argument, we need to turn to evolutionary biology.

3. Comparison and Complexity: Methods for Studying Cognitive Adaptations. It is hard to demonstrate conclusively that natural selection shaped extinct populations. This problem is particularly acute for evolutionary psychology because behaviors and cognitive mechanisms do not leave any fossils. In a previous paper, we argued that evolutionary psychologists can draw upon evolutionary biology's impressive array of tools to determine whether a given trait is likely to be an adaptation (see, e.g., Rose and Lauder 1996). In particular, we suggested that the comparative method and complexity arguments can be used to show that mental traits are adaptations. (Grantham and Nichols, 1999) In this section, we explain how these strategies can be used to support adaptationist accounts of cognitive mechanisms and consider briefly whether these strategies can be applied to phenomenal consciousness.

3.1. Comparative Arguments. The comparative method is one of the most important techniques for formulating and testing natural selection hypotheses. (Krebs and Davies 1984; Harvey and Pagel 1991) Two different kinds of comparison are generally used. First, morphological and behavioral differences among closely related species may indicate adaptive divergence—especially if morphological traits correlate with ecological variables. Second, if distantly related species found in similar niches display similar morphologies, then this may indicate that the morphological traits are adaptations to that niche.

The well-known case of testis size in primates illustrates how comparative biology can support the claim that a trait is an adaptation. Chimpanzees have much larger testes than the other great apes (humans, gorillas, orangutans). This difference among closely related species suggests

that large testis size might be because of sperm competition. Chimps live in multi-male troops and females often mate with multiple males during estrus. Males who produce more sperm should have an advantage in sperm competition. Gorillas and orangutans have strikingly different mating systems: only one male has access to females during estrus. Harcourt and colleagues (1981) gathered additional comparative data to test this hypothesis. Even after accounting for the fact that testis size tends to increase with body size, genera with multi-male breeding systems have significantly larger testes than closely related genera with monogamous or single-male breeding systems. This comparative data confirms the hypothesis that large testis size evolved to aid in sperm competition within multi-male breeding systems.

The comparative method shows considerable promise for exploring the evolutionary origins of mental traits. For example, comparative psychologists are exploring the relation between the mental capacities of human infants and non-human primates in understanding objects (e.g., Hauser and Carey 1998, Uller et al. 1997). Although this comparative approach to cognitive mechanisms is quite new, it's easy to see how it might help us to determine the evolutionary function of cognitive mechanisms. If we can determine the distribution of a cognitive mechanism across related species, we can explore the ecological similarities and differences between species that have (and those that lack) the cognitive mechanism. This will help to determine whether the trait is an adaptation and the likely evolutionary function of the trait.

The comparative method looks promising for exploring (non-species specific) mental traits, and some have used comparative arguments to maintain that phenomenal consciousness is an adaptation (e.g., Flanagan 1992, 133). However, we think that the comparative method is poorly suited to determining whether phenomenal consciousness is an adaptation. First, we do not have good tests for identifying the presence or absence of consciousness. Despite the lack of good evidence, many philosophers assume that all vertebrates have phenomenal consciousness. We are perfectly willing to adopt this assumption, but that raises a second difficulty. Comparative arguments are only effective when we can compare related species that vary with respect to the trait of interest. If all vertebrates have phenomenal consciousness, it's possible that consciousness evolved only once and was phylogenetically conserved. In sum, we cannot distinguish between species that have and lack consciousness in a fine-grained way; but it is precisely this kind of distinction (between related species that have and lack consciousness) which would be necessary to apply the comparative method. So the comparative method is currently of no use for determining whether phenomenal consciousness is an adaptation.

3.2. Complexity Arguments. The notion of "complexity" has been un-

derstood in a variety of different and sometimes conflicting ways (see, e.g., Wimsatt 1974, McShea 1997, Shanks and Joplin 1999). To complicate matters further, “complexity” is intimately associated with several other contested terms, including “order,” “randomness,” and “organization.” Though the search for a precise definition is worthwhile—particularly when one is working within a well-articulated theoretical or practical context—we will pursue a different method. Instead of offering yet another definition, we articulate the idea of complexity through exemplars, beginning with the vertebrate eye as an example of functional complexity. We then introduce a second exemplar, the lateral line in fish, which allows us to extend the notion of complexity to cases in which we do not have any prior understanding of the function of the organ.¹

Biologists maintain that the only legitimate explanation for complex and seemingly purposeful organs is natural selection. For example, Ridley (1993, ch. 13) argues that natural selection is the only known explanation of “purposive and often complex” adaptations. Ridley is not claiming that all adaptations are complex. In fact, the loss of complexity can be adaptive (e.g., simplification of an intestinal parasite’s digestive system). But if an organ is complex, evolutionary theorists maintain that we can be confident that it is an adaptation. In Pinker and Bloom’s words, “natural selection is the only scientific explanation of adaptive complexity.” (1990, 709)² Thus, the complexity of a trait provides good grounds for thinking the trait is an adaptation, even if we cannot provide a full adaptation explanation for its origin.

This “complexity principle” will not be useful (or testable) unless scientists can actually identify complex traits. Pinker and Bloom assert that complex systems are “composed of many interacting parts where the details of the parts’ structure and arrangement suggest design to fulfill some function.” (1990, 709) That is, complex traits contain a diversity of parts that are organized so that the parts contribute to the achievement of some function.³ To use a hackneyed (but still impressive) example, consider the

1. Throughout this discussion, we will focus exclusively on complexity in *biological* systems.

2. Advocates of “complexity theory” (e.g., Kauffman 1995) maintain that complexity can emerge through a process of “self-organization.” We remain skeptical. To date, complexity theorists have not provided any compelling examples in which functional complexity is explained solely as a result of self-organization.

3. Pinker and Bloom’s claim that “natural selection is the only scientific explanation of adaptive complexity” verges on a tautology. If adaptations are, by definition, the result of natural selection, then all adaptive complexity must be a result of natural selection. One can avoid this potential circularity by distinguishing causal role function and evolutionary function. The fact that the parts are well-organized to achieve a causal role function can be used to support the historical claim that the trait either originated by (or was subsequently shaped by) natural selection.

vertebrate eye. The eye contains a number of parts including the cornea, iris, lens, muscles, and retina. Each of these parts is well-suited to playing some important role in the overall function of the organ: the cornea protects the eye, the iris controls the amount of light entering the eye, the lens focuses light on the retina, muscles allow for variable focus, different cells are sensitive to different wavelengths of light, etc. Thus, the eye is composed of a number of parts, each of which seems to contribute to the organ's ability to achieve the function of vision. There are two primary reasons for thinking that organs with this kind of complexity are adaptations. First, it is highly unlikely that a sequence of undirected and unselected variation could first produce and then coordinate the actions of these multiple sub-units. Second, a complex trait would eventually deteriorate unless it was favored by selection.

Pinker and Bloom (1990) extend the complexity argument to mental traits and appeal to the complexity of language as evidence that language is an adaptation. Recent work in psycholinguistics indicates that the "language organ" contains a number of distinct cognitive processors that interact in complex ways to accomplish the function of understanding language. Psycholinguists maintain that language understanding involves phoneme recognition, phonological analysis, lexical analysis, and parsing among other sub-processes (see, e.g., Caplan 1992). Further, we have reason to think that at least some of these sub-processes are functionally discrete. For instance, Swinney found that semantic lexical analysis is informationally encapsulated. (Swinney 1979) And syntactic comprehension is selectively damaged in Broca's aphasics. (Schwartz et al. 1980) Because the language organ is hypothesized to contain several different sub-mechanisms (differentiation of elements), which interact smoothly and quickly to explain the speed of language understanding (functional coordination of the elements), the language faculty is a promising place to launch a complexity argument.⁴

Complexity arguments have been invoked to argue that phenomenal consciousness is an adaptation (e.g., Flanagan 1992, 134). However, insofar as the complexity arguments rely on the kind of functional complexity exemplified by the eye, these arguments will run up against the problem of epiphenomenalism. In characterizing the complexity of the eye, we assumed that the eye functions to provide visual information about the environment. And it is this background understanding of the function of

4. We have modified Pinker and Bloom's argument somewhat. They argue that the complexity of language (e.g., grammar) is evidence that language is an adaptation. We think that it's more compelling to appeal to the complexity of the cognitive mechanisms underlying language comprehension (or production) as evidence that the capacity to understand (or produce) language is an adaptation (see Grantham and Nichols 1999).

the eye which supports the claim that the various components of the eye are ‘well-suited’ to facilitate vision. To deploy a similar complexity argument for phenomenal consciousness would require prior knowledge of the function of phenomenal consciousness, and thus would beg the question against the epiphenomenalist.

4. “Anatomical” Complexity and Phenomenal Consciousness. Although functional complexity arguments for phenomenal consciousness run up against epiphenomenalism, evolutionary biology provides a different kind of complexity argument as well. We will argue in this section that even without specifying the function of phenomenal consciousness, the complexity of phenomenal consciousness indicates that it is an adaptation.

4.1. Anatomical Complexity Arguments in Biology. Although complexity arguments often rely on prior knowledge of what the organ does, knowledge of causal role function is not necessary to launch a complexity argument. Several biological theorists argue that if an organ exhibits sufficient structural complexity, we can infer that the organ is an adaptation, even if we don’t know what the function of the organ is. For instance, Robert Brandon writes,

There are features whose usefulness is unclear for which we still reject chance explanations because of their high degree of complexity and constancy. A good example is lateral lines in fish. This organ is structurally complex and shows a structural constancy within taxa, yet until recently it was not known how the lateral line was useful to its possessor.” (1997, 8)

Brandon’s inference that selection must have shaped the lateral line system is based on the structure of the system, without any knowledge of how the parts interact or any knowledge of the function of the system. We refer to this as an “anatomical” complexity argument to distinguish it from traditional complexity arguments that draw freely on prior knowledge of the function(s) of the organ.

The lateral line system mentioned by Brandon above provides one influential example of an anatomical complexity argument. But it is hardly the only such argument. Another well-known anatomical complexity argument concerns Lorenzini’s ampullae. Sharks have several globular structures, ampullae, located throughout the head region, and these structures are always associated with the nervous system. Even before their function was known, the complexity of the ampullae was so apparent that biologists assumed the ampullae must have some biological function. Biologists eventually found that the ampullae functioned to aid sharks in finding prey in the mud. Maynard Smith describes the example as follows:

“Curio (1973) makes the valid point that the ampullae of Lorenzini in elasmobranchs were studied for many years before their role in enabling fish to locate prey buried in the mud was demonstrated, yet the one hypothesis that was never entertained was that the organ was functionless.” (Maynard Smith 1978, 97) The complex structure of the ampullae suggests that they are adaptations, even if we have no idea about the function of the organ.

Returning to our initial example, the lateral line system in fish is composed of several distinct “lateral line organs” located along the length of the fish, which provide input to the lateral line nerve (see Figure 1). Curio (1973) and Brandon (1997) both note that biologists inferred that the lateral line system was an adaptation before they knew the function of the system. Biologists now maintain that the lateral line system helps the fish to gauge water currents, and to monitor low-frequency sounds and pressure waves from moving objects. Among other things, this helps fish to locate prey.

One reason for treating anatomical complexity as evidence of adaptation is that the construction of a complex trait requires energy. As a result, complex traits that do not enhance fitness will either passively deteriorate or be actively selected against. The lateral line system contains a number of elements: a system of tubular channels, the lateral line organs, and the nerves which are connected to the lateral line organs. Furthermore, the various elements of the lateral line system stand in particular spatial relations: the channels extend all the way to the fish’s outer surface, the lateral line organs always protrude slightly into the channel *and* connect to a nerve, etc. These spatial relations are regularly repeated among con-specific organisms. The precise spatial arrangement of the elements is one of the striking features of the lateral line system. Presumably, it takes a significant amount of energy and special genetic/developmental mechanisms to create these structures and to ensure that they are connected in the correct way. Because these structures (and their spatial relations) are reliably formed even though they are energetically expensive, one suspects that they perform some significant (fitness enhancing) function. If they did not perform any function, one would expect them to deteriorate.

The supposition that the lateral line deteriorates when it is not needed has been confirmed through comparative studies. In one genus of hagfish, the Myxinids, the lateral line system is absent, whereas in another genus, the Eptatretids, the lateral line system is sometimes present. This difference among hagfish species is explained by evolutionary considerations:

Hagfish in general are burrowers, spending much of their time buried up to their snouts in soft clay or silt . . . It is reasonable to assume that skin pressed to clay permits little water flow past superficial lat-

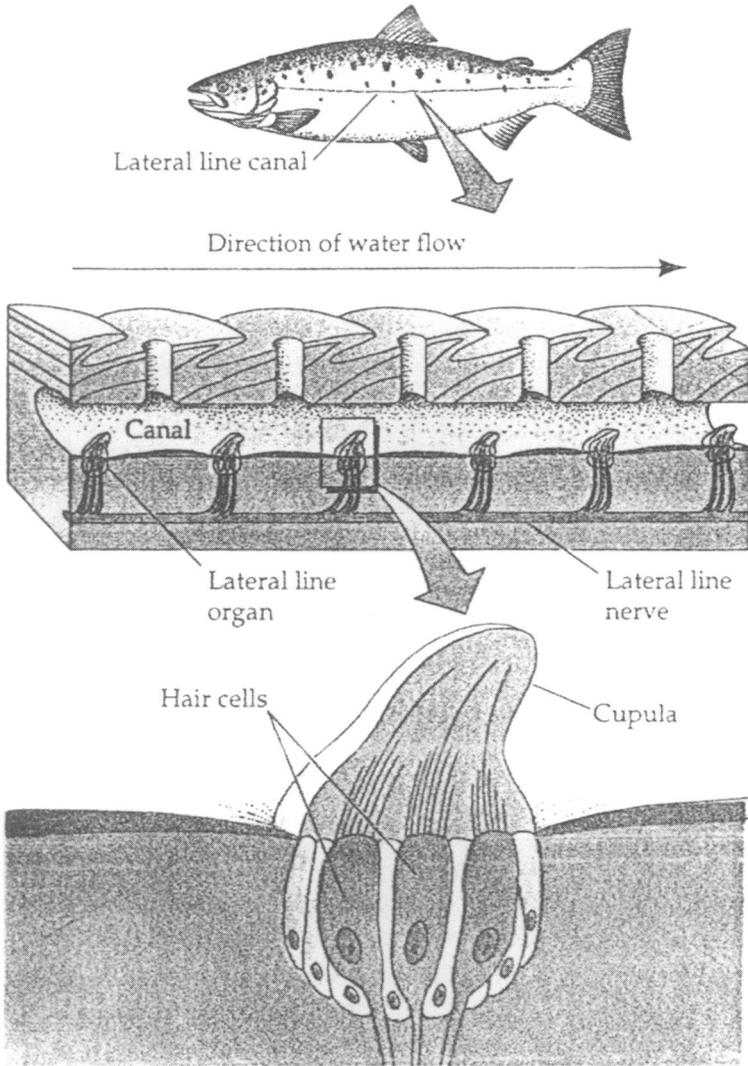


Figure 1. The lateral line system (from Purves et al. 1992, 852).

eral line organs. . . . While both genera of hagfish burrow, there are anecdotal data that suggest eptatretids spend less time in burrows and may prefer rocky substrata . . . This difference may explain the difference in distribution of lateral line systems in the two genera. Regressive evolution has been in progress since the ancestors of hagfishes burrowed in the substrates, and has culminated in the complete loss

of the system in myxinids, while the eptatretids have retained some vestige of a system that might still function while above the substrate. (Braun and Northcutt 1998, 528)

In sum, the lateral line system in fish exhibits a kind of anatomical complexity that provided strong *prima facie* evidence that the system is an adaptation. Further research exposed the likely evolutionary function of the system. And more recently, scientists have found that the lateral line system has deteriorated in species for which it is no longer useful.

4.2. Complexity of Phenomenal Consciousness. We maintain that phenomenal consciousness shows a structural complexity analogous to that of the lateral line system. But we want to begin with a couple of caveats. For the purposes of our discussion, we will put the problem of other minds to the side and simply assume that humans are conscious. We will also rely largely on self report in characterizing phenomenal consciousness.⁵ There are obvious shortcomings with this source, but presumably any characterization of phenomenal consciousness will rely on self report. We will argue that even without specifying any function of phenomenal consciousness, there is reason to think that consciousness is a complex system that unites input from a number of independent channels.

4.2.1. Unity of Consciousness. The claim that phenomenal consciousness is unified has a long history stretching through Kant and Descartes. More recently, John Searle has argued that the unity of consciousness is an obvious feature of phenomenal consciousness that any theory of consciousness needs to accommodate. Searle notes that consciousness enjoys two kinds of unity. First, conscious experience is unified across short temporal spans. (Searle 1992, 130) For example, our grasp of a musical line requires that we have an awareness of the first notes while we are hearing the last notes. The second kind of unity is “the simultaneous awareness of all the diverse features of any conscious state.” (Searle 1992, 130) Searle writes,

I do not just have an experience of a toothache and also a visual experience of the couch that is situated a few feet from me and of roses that are sticking out from the vase on my right, in the way that I happen to have on a striped shirt at the same time as I have on dark

5. So, in this sense, we are not addressing a truly thorough-going epiphenomenalism according to which phenomenal consciousness doesn't even affect self report. Most of the recent discussion of epiphenomenalism has focused on the weaker version of epiphenomenalism according to which self report *is* affected by phenomenal consciousness (e.g., Block 1995; Chalmers 1996).

blue socks I have my experiences of the rose, the couch, and the toothache all as experiences that are part of one and the same conscious event. (1992, 129–130)

Searle claims that without these kinds of unity we “could not make normal sense of our experience.” (130) For our purposes, the important claim is that lots of experiences from within and across modalities can be included in the same conscious state.

Although Searle maintains that the unity of consciousness is an obvious and essential feature of phenomenal consciousness, some researchers have suggested that the unity of consciousness might be an illusion. If the apparent unity of phenomenal consciousness is completely illusory, then our complexity argument will fail. We are not inclined to get into the debate over the unity of consciousness, but we would like to note that many of the complaints against the unity of consciousness are orthogonal to our concerns. For instance, many have noted that conscious experience is heterogeneous (e.g., Dennett 1991, Flanagan 1995). Phenomenal consciousness is not, even subjectively, homogeneous, and it can be important to distinguish between different kinds of conscious experience. For instance, Flanagan maintains that phenomenal dreaming is a “good example of one of the heterogeneous kinds of conscious experience.” (1995, 1108) But notice that this doesn’t threaten the claim that phenomenal consciousness is unified in the senses outlined by Searle—indeed, a salient fact about phenomenal dreaming is that it displays unity in a way similar to waking experience. A rather different attack on the unity of consciousness challenges the breadth of the putative unity. Several writers have suggested that perhaps there isn’t a single center of phenomenal consciousness in the mind (e.g., Flanagan 1992, 191; Young 1994, 195). For our account, what will matter is not whether there is a single sphere of phenomenal consciousness in all normal humans. Rather, what will matter for us is that there is *at least one* system of phenomenal consciousness in normal humans that shows unity in including lots of experiences from different mechanisms in the same conscious event. If it turns out that there are also additional independent systems of phenomenal consciousness, *that* kind of disunity needn’t be troubling for our account.

For the remainder of the paper, we’re going to adopt the assumption that the phenomenal consciousness system that underlies self report is unified. And when we refer to the phenomenal consciousness system, it is this unified system that we have in mind. If this assumption turns out to be a little bit off, such that there are a few phenomenal consciousness systems, that is probably okay for our argument. However, if the assumption turns out to be wildly false, such that there is really no system of phenomenal consciousness that unites lots of different experiences, then

our argument will be defeated. However, there is little reason to think that the unity assumption is *that* wildly off-base, so we propose not to worry about it for the time being.

4.2.2. Multiple Input Mechanisms. Our second claim about the structure of phenomenal consciousness is that it draws information through several independent input channels. The clearest evidence for this comes from work on dissociations in neuropsychology. Neuropsychologists have found that selective brain damage can produce selective deficits in phenomenal consciousness. This evidence, together with the claim that phenomenal consciousness is unified, suggests that phenomenal consciousness is a complexly structured system.

A wide range of evidence from neuropsychology suggests that subjects can have perceptual information in the mind without having that information in phenomenal consciousness. Blindsight is the paradigm example here. The striate cortex is damaged in blindsight patients, and these patients claim to be blind in a certain part of their visual field. However, these patients can ‘guess’ with impressive accuracy about what is in their ‘blind’ field. Apparently then, in blindsight, the visual information is present in the brain, but the information does not reach the phenomenal consciousness system that’s reflected in self report. (Flanagan 1992, 141; Block 1995, 232) Such visual information *does* reach phenomenal consciousness when the striate cortex is intact. Perhaps the most natural and influential explanation of blindsight is that there is an independent ‘input channel’ between the visual information and the phenomenal consciousness system and that this input channel is impaired in blindsight (e.g., Weiskrantz 1988, 188). In blindness, the visual information doesn’t get into the mind at all. But in blindsight, visual information about the ‘blind’ field gets into the mind without reaching phenomenal consciousness. This suggests that there is a further pathway between perceptual information and phenomenal consciousness. Furthermore, this impairment doesn’t disrupt other perceptual information from reaching phenomenal consciousness. Blindsight patients claim to have phenomenal consciousness for auditory information, tactile information, and so forth. Blindsight seems to be a selective deficit in which one input channel between perceptual information and phenomenal consciousness is blocked, while the other input channels remain intact.

Blindsight is the most famous example of a dissociation between perceptual information and phenomenal consciousness, but there are a number of analogous dissociations, suggesting that there are a number of independent input channels that can be selectively damaged (see Shallice 1988, Weiskrantz 1997, and Young 1998 for reviews). For instance, researchers claim to have found a tactile analogue to blindsight, “blind-

touch” or “numbsense”, in which the patient claims not to be aware of stimuli applied to her hand, but she can make accurate “guesses” about the stimuli. (Paillard et al. 1983; Rossetti et al. 1995) There is also a report of an auditory analogue to blindsight, “deaf hearing.” (Michel and Peronnet 1980, cited in Weiskrantz 1997) There is also a kind of dissociation found in visual presentation of words. Block writes, “Alexia is a neurological syndrome whose victims can no longer read a word ‘at a glance,’ but can only puzzle out what word they have seen at a rate of, say, one second per letter. Nonetheless, these subjects often show various kinds of understanding of the meanings of words that have been flashed far too briefly for them to read in their laborious way.” (Block 1995, 230) Each of these cases suggests an independent input channel to the phenomenal consciousness system. For in each case, the information is in the mind, but not in phenomenal consciousness, despite the fact that phenomenal consciousness is still intact and receiving input through other channels. A natural inference is that the input channel between the information and phenomenal consciousness is disrupted, but that the other input channels are left intact.

It’s worth noting that in the visual modality alone, there seem to be multiple input channels to phenomenal consciousness. Prosopagnosiacs claim to have no phenomenal consciousness of facial recognition, but some prosopagnosiacs can make accurate “guesses” about faces. Patients with simultagnosia are unable to attend to more than one object at a time. However, these subjects do show some perception of objects they deny seeing. For instance, when shown a global “H” made up of either small S’s or small H’s, the subjects claim to see only the small letter, but their response time is faster when the small letter and the global letter are both H’s. (Rafal 1997) Patients with apperceptive visual agnosia are unable to name or match simple shapes like squares. Yet in at least one patient with this condition, studies indicated that the subject would orient her hand in the geometrically appropriate ways to grasp objects. (Milner and Goodale 1995) When subjects with extinction are asked to say what they are seeing, they tend to ignore the object shown on the side opposite the damaged hemisphere, and sometimes even deny seeing anything on that side. Yet these subjects do well if asked whether the objects are the same or different, and this has been interpreted as evidence that the information is not appropriately transferred to consciousness. (Volpe et al. 1979) Finally, some patients exhibit achromatopsia, a condition in which people claim to see only in black and white, but can in fact make some color discriminations. Young writes, “In cases of achromatopsia . . . there is evidence that some aspects of color processing mechanisms continue to function. . . . However . . . there is no subjective experience of color.” (Young 1994, 179) In each of these cases, it seems that there is a selective disconnection between a

certain kind of visual information and conscious awareness of the information.

The neuropsychological evidence suggests that phenomenal consciousness receives information from several independent input channels. While some of these findings might be given alternate interpretations (see Farah and Feinberg 1997 for discussion), if anything much like what we've sketched is right, then there are numerous different channels feeding into phenomenal consciousness. Indeed, there seem to be numerous different channels feeding into visual experience alone.⁶ If this account is on target, then the phenomenal consciousness system exhibits a level of anatomical complexity that plausibly requires an adaptation explanation. Indeed, the structure of phenomenal consciousness is strikingly similar to the structure of the lateral line system. Both systems have several independent input channels that feed into a more central mechanism. Just as it takes energy to develop and maintain the network of channels and lateral line organs in fish, it must take energy to create and maintain a system of multiple channels that provides input into phenomenal consciousness. If this kind of structure did not perform any function, it would passively deteriorate or be actively selected against.

Obviously there are differences between the lateral line system and phenomenal consciousness. We will comment on two disanalogies. First, there is probably a quantitative difference in the number of input channels. The lateral line system consists of dozens of distinct input channels and the phenomenal consciousness system likely has fewer input channels. We see no reason why this quantitative difference should undermine our argument. In fact, other considerations suggest that phenomenal consciousness may be more complex than the lateral line system. The input channels in the lateral line system are all anatomically similar and provide the same kind of information. In contrast, the input channels for phenomenal consciousness convey different kinds of information: one channel delivers visuo-facial experience; another delivers color experience; a third delivers tactile experience, etc. Insofar as conveying different kinds of information requires differentiation of the channels, the phenomenal consciousness system contains a greater diversity of specialized input structures than the lateral line system.

The second disanalogy is that the operative notion of "channel" is slightly different in the two cases. The channels and lateral line organs are

6. As a result, even if consciousness is not unified across sensory modalities, one might rely on the evidence from visual experience to argue that there is a system of phenomenal consciousness that exhibits sufficient complexity to indicate that it's an adaptation. On this version of the argument, one need only assume unity of consciousness for the visual modality.

visible anatomical structures. In contrast, the evidence for multiple “input channels” to phenomenal consciousness is less direct. Since several different kinds of information can be present in the mind and yet not available to phenomenal consciousness (even while other forms of sensory input successfully reach phenomenal consciousness), it is reasonable to infer that the “channels” which carry these sensory inputs are physically distinct. Although these functionally characterized input channels are not directly visible, they must be realized by some kind of (costly) neural structure. And, as we have argued above, one would expect that a complex network of channels would deteriorate if it did not perform any useful function.

As with the lateral line system, then, we maintain that consciousness exhibits sufficient complexity to indicate that it’s an adaptation. Recall Maynard Smith’s remark that before researchers knew the function of ampullae, “the one hypothesis that was never entertained was that the organ was functionless.” (1978) We suspect that if given an abstract characterization of the structure of phenomenal consciousness, biologists wouldn’t even entertain the hypothesis that the system is functionless. Indeed, we *have* asked a number of biologists, and they have all answered that they would expect the system, so described, to be an adaptation.⁷

For those with an abiding metaphysical conviction that phenomenal consciousness can’t be causally relevant, our complexity argument is unlikely to carry much weight. However, if we view phenomenal consciousness from the perspective of biology rather than metaphysics, we have good reason to think that phenomenal consciousness is an evolutionary adaptation and hence causally relevant.

5. Epiphenomenal Complexity. If, as we have suggested, phenomenal consciousness is an adaptation, it follows that epiphenomenalism is false. For if phenomenal consciousness is adaptive, it must affect behavior in some way that impacts fitness. It must have served some evolutionary function, hence it must have some causal role function, complete with outputs.⁸ In reply, an epiphenomenalist might object that the apparent complexity

7. Our argument differs from Flanagan’s psychopathology argument (section 2) in an important way. Flanagan infers evolutionary and causal role function from the correlation between loss of cognitive function and loss of phenomenal consciousness. Because this style of argument is based on correlation data, it is subject to Block’s worry that the loss of function is due to disruption of something other than phenomenal consciousness. In contrast, we draw on similar data on psychopathologies to develop an understanding of the structure of phenomenal consciousness *per se*. By showing that phenomenal consciousness *per se* has this structure, our argument provides a more direct response to Block’s worry about phenomenal consciousness (see section 5).

8. Strictly speaking, what follows is somewhat weaker – if phenomenal consciousness

of phenomenal consciousness is misleading.⁹ We want to distinguish two different kinds of epiphenomenalist arguments here:

- (1) The apparent complexity of phenomenal consciousness is only apparent, thus there's no reason to think that it is an adaptation.
- (2) The apparent complexity of phenomenal consciousness may be inherited from access consciousness, thus there's no reason to think that phenomenal consciousness is an adaptation.

In response to (1), we agree that if phenomenal consciousness only *appears* to be complex, then our argument is thoroughly compromised. But the mere possibility that phenomenal consciousness isn't really complex isn't enough to undermine the view. This objection only works if we have independent reason to think that the apparent complexity of phenomenal consciousness is only apparent. Consider, by analogy, the case of the ampullae. It's *possible* that ampullae only *appear* to be complex, but that bare possibility certainly doesn't vitiate the argument that ampullae are adaptations. From a biological perspective, merely claiming that there *might* be an alternative is hardly a criticism. The complexity argument creates a presumption that phenomenal consciousness is an adaptation, thus the critic has a burden to present evidence to overturn the presumption.

Argument (2) might be regarded as an attempt to supply a real alternative, namely, that access consciousness produces the apparent complexity in phenomenal consciousness. We concede that future scientific developments might support this alternative interpretation, but we maintain that our complexity argument now places the burden of proof on the epiphenomenalist. And it is a significant burden. To defend the claim that the phenomenal consciousness system inherits its complexity from some other system, one would have to show (a) that a second (presumably complex) system exists, and (b) that the complexity of phenomenal consciousness is a free rider. Thus, the advocate of (2) must show that the access consciousness system is structurally distinct from the phenomenal consciousness system we have been discussing. To see why, consider the lateral line system in fish. Someone might claim that the lateral line system isn't an adaptation, but inherits its complexity from the organ that monitors water currents and water pressure. This "objection" does not offer a competing hypothesis unless one already has reason to claim that some other

is an adaptation, then it must have *had* a causal role function in the past. As we'll see in section 6, however, there is good reason to think that phenomenal consciousness still has a fitness-enhancing causal role function.

9. This objection was pressed in different ways by Elizabeth Meny and by Martin Perlmutter.

organ has the monitoring function. Similarly, to claim that phenomenal consciousness isn't really complex but inherits its complexity from the organ that has the function of access consciousness doesn't provide an alternative (competing) hypothesis unless one has independent evidence that the function of access consciousness is subserved by a system other than phenomenal consciousness. If, on the other hand, the function of access consciousness is partly achieved by the phenomenal consciousness system, then phenomenal consciousness remains an adaptation: it is one of the structures which has been shaped by natural selection to perform the function of access consciousness.

Our reply to (2) is perfectly consistent with the claim that phenomenal consciousness and access consciousness can be distinguished, conceptually and empirically (cf. Shoemaker 1981, Dennett 1991, Flanagan 1992). For even if the evolutionary function of phenomenal consciousness is access consciousness, it doesn't follow that there is any conceptual or nomologically necessary identity between phenomenal consciousness and access consciousness. Our account is accordingly neutral about the possibility of zombies. The possibility that evolution might have secured access consciousness without phenomenal consciousness does not undermine the claim that in fact, the evolutionary function of phenomenal consciousness is access consciousness. For the claim that a mechanism evolved to serve some function is not refuted by showing that a different mechanism could also serve that function. Indeed, in the same organism there can be multiple mechanisms that can serve the same function. To take a crude example, one crucial function of the opposable thumb is grasping; however, people who have lost the use of their hands can develop a serviceable grasping capacity with their toes. In light of this, consider again Humphrey's monkey Helen. The fact that Helen seems to have acquired a kind of access consciousness in the absence of phenomenal consciousness does not show that the evolutionary function of phenomenal consciousness is not access consciousness. What it might instead show is a kind of plasticity of mind that allows the function of access consciousness to be served even in the absence of phenomenal consciousness.

Thus, the evolutionary approach suggests a new way to respond to the epiphenomenalist. In light of the apparent complexity of phenomenal consciousness, to deny that phenomenal consciousness serves a function is a theoretical excrescence.

6. Adaptive Complexity and the Causal Role Function of Phenomenal Consciousness. Not only can the complexity of a system indicate that the system is an adaptation, the nature of the complexity can provide clues about the function of the system. For if a complex organ was selectively advantageous, then the characteristics that make the organ complex probably

contributed to fitness. Thus, the following seems to be a plausible Principle of Adaptive Complexity:

If a trait exhibits sufficient complexity to indicate that the trait is an adaptation, the complexity of the trait is probably functionally relevant. That is, the features that make the organ complex likely contribute to its adaptedness.

This is an important feature of complexity arguments, and it can play a role in specifying the function of the organ when the complexity is recognized before the function is.¹⁰ We recognize that inferences from structure to function can go wrong in a variety of ways (see, e.g., Lauder 1996). Nonetheless, we think that the Principle of Adaptive Complexity provides important clues about the evolutionary function of consciousness.

In the case of the lateral line system, the Principle of Adaptive Complexity suggests that the lateral line system integrates information transmitted through the lateral line organs. That seems to be the best explanation for why there are so many distinct lateral line organs feeding into the lateral line nerve. Obviously, this account is still seriously underdescribed as a functional characterization. Even if the function of the lateral line system is information integration, this still doesn't tell us what information gets integrated. We certainly couldn't conclude simply from the Principle of Adaptive Complexity that the lateral line system computes information about water current and water pressure.

Just as the complex structure of the lateral line system indicates that the system integrates information from the lateral line organs, it seems that the similarly complex structure of phenomenal consciousness indicates that phenomenal consciousness integrates information received from the independent input channels. Obviously, this 'information integration' proposal is an extremely thin account of the function of phenomenal consciousness, and a much more detailed defense would be required to make this account persuasive. But the general picture of the function of phenomenal consciousness that emerges is close to Fodor's notion of "horizontal faculty". Fodor (1983) describes a horizontal faculty as a "functionally distinguishable cognitive system whose operations cross content domains" (13); horizontal systems "operate, *inter alia*, to exploit the information that the input systems provide." (103) The proposal, then, is that phenomenal consciousness is a horizontal faculty that integrates information from independent input channels to produce outputs that are sensitive to the range of inputs. On this proposal, it is plausible that the integration function would have been adaptively important. The integra-

10. Our suggestions on complexity and evolutionary function were influenced by Pevskey and Block (1990).

tion of inputs from various mechanisms would enable the organism to behave in a way that is sensitive to a wide range of information across different modalities.

The Principle of Adaptive Complexity only provides a thin characterization of the function of phenomenal consciousness. But if the epiphenomenalist threat is quelled by the complexity argument, then we might appeal to other sources of evidence to further characterize the function of phenomenal consciousness. In particular, we can exploit the evidence from psychopathologies again, but not to combat epiphenomenalism; rather, we can consult the evidence simply to see what causal functions are disrupted when information does not reach phenomenal consciousness. At this point, we can return to the evidence that patients with deficits in phenomenal consciousness exhibit corresponding deficits in rational action (e.g. Marcel 1986, Van Gulick 1989, Flanagan 1992). This suggests that the function of phenomenal consciousness is indeed something like access consciousness. For it seems that phenomenal consciousness serves the function of integrating information in the service of reasoning and action. No doubt this is still a vastly oversimplified account of the function of phenomenal consciousness. But even in the absence of a more developed account, it's plausible that having a system that performs this function of integration and access was adaptive for our ancestors and that it continues to be important for our biological success.

7. Conclusion. Several philosophers maintain that we need to think about phenomenal consciousness as just another biological phenomenon. We have argued that if we approach the issue in a relentlessly biological fashion, the apparent complexity of phenomenal consciousness indicates that it is an adaptation. Given the apparent complexity of phenomenal consciousness, evolutionary principles suggest that it's *prima facie* implausible that phenomenal consciousness doesn't do anything. Furthermore, if this complexity argument works, it provides the basis for developing an account of the function of phenomenal consciousness as well.

REFERENCES

- Block, Ned J. (1995), "On a Confusion about a Function of Consciousness", *Behavioral and Brain Sciences* 18: 227–287.
- Brandon, Robert N. (1997), *Concepts and Methods in Evolutionary Biology*. Cambridge: Cambridge University Press.
- Braun, Christopher B. and R. Glenn Northcutt (1998), "Cutaneous Exteroreceptors and Their Innervation in Hagfishes", in J. Jorgenson, J. Lomholt, R. Weber, and H. Malte (eds.), *The Biology of Hagfishes*. New York: Chapman and Hall, 510–530.
- Caplan, David (1992), *Language*. Cambridge, MA: MIT.
- Chalmers, David (1996), *The Conscious Mind: In Search of a Fundamental Theory*. New York: Oxford University Press.
- Curio, E. (1973), "Towards a Methodology of Teleonomy", *Experientia* 29: 1045–1058.

- Dennett, Daniel C. (1991), *Consciousness Explained*. Little Brown.
- Farah, Martha J. and Todd E. Feinberg (1997), "Perception and Awareness", in T. Feinberg and M. Farah (eds.), *Behavioral Neurology and Neuropsychology*. New York: McGraw-Hill, 357–368.
- Flanagan, Owen (1992), *Consciousness Reconsidered*. Cambridge, MA: MIT.
- . (1995), "Consciousness and the Natural Method", *Neuropsychologia* 33: 1103–1115.
- Flanagan, Owen and Thomas Polger (1995), "Zombies and the Function of Consciousness", *Journal of Consciousness Studies* 2: 313–21.
- Fodor, Jerry A. (1983), *Modularity of Mind*. MIT Press.
- Grantham, Todd and Shaun Nichols (1999), "Evolutionary Psychology: Ultimate Explanations and Panglossian Predictions", in V. Hardcastle (ed.), *Biology Meets Psychology: Connections, Constraints, Conjectures*. Cambridge, MA: MIT Press, 47–66.
- Harcourt, Alexander H., Paul H. Harvey, Susan G. Larson, and Roger V. Short (1981), "Testis Weight, Body Weight and Breeding System in Primates", *Nature* 293: 55–57.
- Harvey, Paul H. and Mark D. Pagel (1991), *The Comparative Method in Evolutionary Biology*. Oxford: Oxford University Press.
- Hauser, Marc and Susan Carey (1998), "Building a Cognitive Creature from Set of Primitives: Evolutionary and Developmental Insights", in D. Cummins and C. Allen (eds.), *The Evolution of Mind*. New York: Oxford, 51–106.
- Humphrey, Nicholas (1974), "Vision in a Monkey without a Striate Cortex: A Case Study", *Perception* 3: 241–255.
- . (1995), "Blocking Out the Distinction between Sensation and Perception: Superblindsight and the Case of Helen", *Behavioral and Brain Sciences* 18: 257–258.
- Kauffman, Stuart (1995), *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*. New York: Oxford University Press.
- Krebs, J. R. and Nicholas B. Davies (eds.) (1984), *Behavioural Ecology*, (2nd ed). Oxford: Blackwell.
- Lauder, George V. (1996), "The Argument from Design", in Rose and Lauder 1996, 55–91.
- Marcel, Anthony (1986), "Consciousness and Processing: Choosing and Testing a Null Hypothesis", *Behavioral and Brain Sciences* 9: 40–41.
- Marshall, John C. and Peter W. Halligan (1988), "Blindsight and Insight in Visuo-Spatial Neglect", *Nature* 336: 766–767.
- Maynard Smith, John (1978), "Optimization Theory in Evolution", *Annual Review of Ecology and Systematics* 9: 31–56. Reprinted in Sober 1994, 91–117. Page references to Sober.
- McShea, Daniel (1997), "Complexity in Evolution: A Skeptical Assessment", *Philosophica* 59: 79–112.
- Michel, F. and F. Peronnet (1980), "A Case of Cortical Deafness: Clinical and Electrophysiological Data", *Brain Language* 10: 367–377.
- Milner, A. D. and Melvyn A. Goodale (1995), *The Visual Brain in Action*. New York: Oxford University Press.
- Paillard, Jacques, F. Michel, and George E. Stelmach (1983), "Localization without Content: A Tactile Analog of 'Blind Sight'", *Archives of Neurology* 40: 548–51.
- Pesetsky, David and Ned J. Block (1990), "Complexity and Adaptation", *Behavioral and Brain Sciences* 13: 750–752.
- Pinker, Steven and Paul Bloom (1990), "Natural Language and Natural Selection", *Behavioral and Brain Sciences* 13: 707–784.
- Polger, Thomas and Owen Flanagan (forthcoming), "Consciousness, Adaptation, and Epiphenomenalism", in G. Mulhausen (ed.), *Evolving Consciousness*. Philadelphia: John Benjamins.
- Purves, W., G. Orians, and H. Heller (1992), *Life: The Science of Biology*. Sinauer.
- Rafal, Robert D. (1997), "Balint Syndrome", in T. Feinberg and M. Farah (eds.), *Behavioral Neurology and Neuropsychology*. New York: McGraw-Hill, 337–356.
- Ridley, Mark (1993), *Evolution*. Oxford: Blackwell.
- Rose, Michael R. and George V. Lauder (1996), *Adaptation*. Academic Press.
- Rossetti, Yves, Gilles Rode, and Dominique Boisson (1995), "Implicit Processing of So-

- maesthetic Information: A Dissociation between Where and How?", *NeuroReport* 6: 506–510.
- Searle, John (1992), *The Rediscovery of Mind*. MIT Press.
- Schwartz, Myrna F., Eleanor M. Saffran, and Oscar S. Marin (1980), "The Word Order Problem in Agrammatism", *Brain and Language* 10: 249–262.
- Shallice, Tim (1988), *From Neuropsychology to Mental Structure*. Cambridge: Cambridge University Press.
- Shanks, Niall and Karl Joplin (1999), "Redundant Complexity: A Critical Analysis of Intelligent Design in Biochemistry", *Philosophy of Science* 66: 268–282.
- Shoemaker, Sydney (1981), "Absent Qualia Are Impossible – A Reply to Block", *Philosophical Review* 90: 481–499.
- Sober, Elliott (ed.) (1994), *Conceptual Issues in Evolutionary Biology*. Cambridge: MIT Press.
- Stich, Stephen P. (1978), "Beliefs and Subdoxastic States", *Philosophy of Science* 45: 499–518.
- Swinney, David (1979), "Lexical Access during Sentence Comprehension: (Re)consideration of Context Effects", *Journal of Verbal Learning and Verbal Behavior* 18: 645–660.
- Uller, Claudia, Fei Xu, Susan Carey, and Marc Hauser (1997), "Is Language Needed for Constructing Sortal Concepts? A Study with Nonhuman Primates", *Proceedings of the 21st Annual Boston University Conference on Language Development*, vol. 2, 665–677.
- Van Gulick, Robert (1989), "What Difference Does Consciousness Make?" *Philosophical Topics* 17: 211–230.
- Volpe, Bruce T., Joseph LeDoux, and Michael Gazzaniga (1979), "Information Processing of Visual Stimuli in an 'Extinguished' Field", *Nature* 282, 722–24.
- Weiskrantz, Lawrence (1988), "Some Contributions of Neuropsychology of Vision and Memory to the Problem of Consciousness", in A. Marcel and E. Bisiach (eds.), *Consciousness in Contemporary Science*. New York: Oxford University Press, 183–199.
- . (1997), *Consciousness Lost and Found*. New York: Oxford University Press.
- Wimsatt, William (1974), "Complexity and Organization", in M. Greene and E. Mendelsohn (eds.), *Topics in the Philosophy of Biology*. Dordrecht: D. Reidel, 174–193.
- Young, Andrew W. (1994), "Neuropsychology of Awareness", in A. Revonsuo and M. Kamppinen (eds.), *Consciousness in Philosophy and Cognitive Neuroscience*. Hillsdale, NJ: LEA, 173–203.
- . (1998), *Face and Mind*. New York: Oxford University Press.