Psychological Review
2005, Vol. 112, No. 4, 1000–1021


0033-295X/05/$12.00 DOI: 10.1037/0033-295X.112.4.1000

# The Function of Phenomenal States: Supramodular Interaction Theory

Ezequiel Morsella
Yale University

Discovering the function of phenomenal states remains a formidable scientific challenge. Research on consciously penetrable conflicts (e.g., "pain-for-gain" scenarios) and impenetrable conflicts (as in the pupillary reflex, ventriloquism, and the McGurk effect [H. McGurk & J. MacDonald, 1976]) reveals that these states integrate diverse kinds of information to yield adaptive action. Supramodular interaction theory proposes that phenomenal states play an essential role in permitting interactions among *supramodular response systems*—agentic, independent, multimodal, information-processing structures defined by their concerns (e.g., instrumental action vs. certain bodily needs). Unlike unconscious processes (e.g., pupillary reflex), these processes may conflict with skeletal muscle plans, as described by the principle of parallel responses into skeletal muscle (PRISM). Without phenomenal states, these systems would be encapsulated and incapable of collectively influencing skeletomotor action.

*Keywords:* phenomenal states, function of consciousness, consciousness, awareness, cognitive processes

Discovering the function of phenomenal states remains one of the greatest challenges for psychological science (Baars, 1998, 2002; Bindra, 1976; Block, 1995; Chalmers, 1996; Crick & Koch, 2003; Donald, 2001; Dretske, 1997; Jackendoff, 1990; James, 1890; Mandler, 1998; Searle, 2000; Shallice, 1972; Sherrington, 1906; Sperry, 1952; Wegner & Bargh, 1998). These enigmatic phenomena, often referred to as "subjective experience," "qualia," "sentience," "consciousness," and "awareness," have proven to be difficult to describe and analyze but easy to identify, for they constitute the totality of our experience. Perhaps they have been best defined by Nagel (1974), who claimed that an organism has phenomenal states if there is *something it is like* to be that organism—something it is like, for example, to be human and experience pain, love, breathlessness, or yellow afterimages. Similarly, Block (1995) claimed, "The phenomenally conscious aspect of a state is what it is like to be in that state" (p. 227). In this article, I present a theory that addresses a simple question: What do these states contribute to the cognitive apparatus and to the survival of the human organism?[1]

Although current theories of nervous function can explain mental phenomena that baffled scientists less than 50 years ago, we are still at a loss for words when explaining the primary, functional role of these states. We can explain, for example, associative learning through Hebbian synapses (but see Gallistel & Gibbon, 2001), pattern completion and categorization in terms of autoassociator networks (Hopfield, 1984), and both recognition and recall by single-system connectionist networks (Kinder & Shanks, 2003; for a thorough account of neural networks and brain function, see Rolls & Treves, 1998). The conceptual understanding of how these processes may be carried out is a great intellectual achievement. However, as in Sherrington's (1906) time, when the operations of the nervous system were understood as the systematic interactions among sensory receptors, interneurons, and effector organs,[2] contemporary accounts of how we function as cognitive organisms leave no functional role for what we identify as phenomenal experience (see next section for notable exceptions).

Furthermore, outside of current explanatory models, contemporary findings in fields as diverse as cognitive psychology (Logan, Taylor, & Etherton, 1999), social psychology (see review in Dijksterhuis & Bargh, 2001), and neuropsychology (see review in Frith, Blakemore, & Wolpert, 2000) have demonstrated that, contrary to what our subjective experience leads us to believe, many of our complex behaviors and mental processes can occur without the guidance of phenomenal processing. That is, they can occur automatically, determined by causes far removed from our awareness (e.g., unconscious or covert priming). There is evidence suggesting, for example, that people automatically imitate the postures, facial expressions, and speaking styles of others (Giles, Coupland, & Coupland, 1991) and can automatically prepare to physically interact with objects (Morsella, Levine, & Bargh, 2004; Tucker & Ellis, 2001, 2004). Recent accounts also speak of the

This work was supported by Grant F32 MH069083 from the National Institutes of Health. I gratefully acknowledge the advice of Robert Krauss, Robert Tallarico, John Bargh, Julian Hochberg, Michele Miozzo, Jon Horvitz, Jeffrey Gray, Charles Carver, Kyle Cave, Brian Scholl, Jeremy Gray, Francis Crick, Noam Chomsky, Tory Higgins, Janet Metcalfe, Herb Terrace, David Chalmers, Frank Keil, Marcia Johnson, Christopher Camacho, Taosheng Liu, Mark Graham, and Douglas Mitchell and the assistance of the neurologist Stephen Krieger.

Correspondence concerning this article should be addressed to Ezequiel Morsella, Department of Psychology, Yale University, 2 Hillhouse Avenue, New Haven, CT 06520. E-mail: ezequiel.morsella@yale.edu

[1] At this stage of understanding, I limit the discussion to humans, for human cognition is the only realm in which one can speak about phenomenal states with any certainty. It remains an open question whether these states are featured in other species. Some evolutionists (Gould, 1977) have regarded the appearance of these states as one of the most consequential biological events since the Cambrian Explosion some 600 million years ago.

[2] Surprisingly, unlike Pavlov (1927), Sherrington (1906) found it mind-boggling that something like phenomenal states could ever be understood in a mechanistic, reductionistic fashion.

automaticity of higher level processes (Bargh & Ferguson, 2000), as in the unconscious evaluation of perceptual stimuli (Duckworth, Bargh, Garcia, & Chaiken, 2002) and the unconscious initiation of, and successful execution of, goal pursuit (Bargh, 1990). It seems that the processes that once served as the sine qua non of choice and free will—goal pursuit, judgment, and social behavior—can occur without conscious processes, raising again the thorny question, What is consciousness for?

This has been called the "softer problem" of consciousness (Morsella, 2003), to contrast it with the "hard problem" of consciousness (Chalmers, 1995), which involves explaining how brain tissue, or any physical system for that matter, can give rise to conscious experience. The difficulty of the hard problem can be readily appreciated by considering that, although we have a conceptual understanding of how lungs, kidneys, and hearts function (though we may not be very good at constructing them), we do not have as much as an inkling regarding how the nuts and bolts of the nervous system engender phenomenal states (Eccles & Popper, 1977).

Some progress regarding the hard problem has been made by attempts to identify the neural correlates of consciousness (NCC). This research shows that phenomenal states are associated with only a subset of all brain regions and processes (Crick & Koch, 1995; Logothetis, 1998; Logothetis & Schall, 1989; Milner & Goodale, 1995; Ortinski & Meador, 2004; Weiskrantz, 1997), providing evidence against the idea that these states are simply a property of the nerve cell or that (an even more panpsychist notion) they are a property of all matter. Data from NCC research may home in on the cell assemblies responsible for phenomenal states and, thus, elucidate the mechanisms by which these states are created (see reviews in Crick & Koch, 2003; Koch, 2004; Pins & Ffytche, 2003; Smythies, 1997). It seems that the solution to the hard problem requires further empirical developments.

In contrast, progress regarding the softer problem has suffered not so much from a lack of relevant data but from the lack of a suitable framework with which to interpret data, which is often the case in the history of psychology (Grossberg, 1987). This has been due to the dominance of behaviorism in the early part of the 20th century and to the prevalence of another tradition that considers all questions regarding the function of phenomenal states to be ill posed.

Some prominent figures (Huxley, 1874; Kinsbourne, 1996, 2000; Pinker, 1997) have proposed that these states serve no role whatsoever—that they are mere epiphenomena (Huxley, 1874). From this standpoint, they are functionless by-products of nervous activity. In a book enticingly titled *How the Mind Works* (1997), Pinker popularized the notion that phenomenal experience is a nonissue that might as well not exist. From this perspective, current nonphenomenal conceptualizations of the nervous system, consisting of structures such as autoassociators and Hebbian synapses, will one day render a complete account of human behavior and mental phenomena (for a treatment of this position, see Dennett, 1991, 2001; Kinsbourne, 2000).[3]

Unfortunately, adopting an epiphenomenal stance leaves us with a number of perplexing issues. For example, it remains an empirical question whether something like today's neural networks are capable of performing all of our cognitive operations and whether these operations are indeed carried out in an analogous fashion by biological systems. It is important to remember that the same operation can be carried out by vastly different mechanisms (Marr, 1982) and that the hands of evolution may solve computational challenges using counterintuitive, nonoptimal strategies that are far different in nature from those of our elegant models (de Waal, 2002; Gould, 1977; Simpson, 1949). Moreover, as scientists, epiphenomenalists must still explain why phenomenal experience seems to be uniquely associated with nervous activity and not with other physical events (e.g., fermentation, photosynthesis, and combustion).

Another problem for epiphenomenalism is the systematic relationship (or, at least, the lack of arbitrariness) between cognitive processes and their epiphenomenal by-products. The valence and other properties of the phenomenal percept are in some ways isomorphic to ongoing action. It is not the case, for example, that pleasant states are associated with avoidant behaviors or that unpleasant ones are associated with approach behaviors—in other words, tissue damage does not happen to feel good and drinking when thirsty does not happen to feel bad. In conclusion, it is not easy to discredit phenomenal states as an object of scientific inquiry. Difficult problems remain.

I favor the view proposed by others of Huxley's era, most notably by Angell (1907) and James (1890), who claimed that these states serve a crucial, adaptive role in the nervous system. In various guises, this position continues today (Baars, 2002; Banks, 1995; Block, 1995; Donald, 2001; Jackendoff, 1990; Mandler, 1998; Shallice, 1972; Sperry, 1952; Schwarz & Clore, 1996; Wegner & Bargh, 1998). This position, too, is based on several assumptions. For example, it is assumed that, without phenomenal states, the cognitive apparatus would not function as it does and that these physical states accomplish something that other, extant forms of nervous events are incapable of achieving. (Again, this does not mean that current models of nervous activity or other contraptions are incapable of achieving what phenomenal states achieve; it means only that, in the course of human evolution, these physical events happened to be what were selected to solve certain computational challenges.)

## The Integration Consensus

Regarding the function of these states, many hypotheses and conjectures have been offered (Baars, 1988, 2002; Block, 1995; Dickinson & Balleine, 2000; Hobson, 2000; Jack & Shallice, 2001; Mandler, 1998; Tulving, 2002). For example, Block (1995) claimed that consciousness serves a rational and nonreflexive role, guiding action in a nonguessing manner; and Baars (1988, 2002) has pioneered the ambitious *conscious access* model, in which phenomenal states integrate distributed neural processes. (For neuroimaging evidence for this model, see review in Baars, 2002.) Others have stated that phenomenal states play a role in voluntary behavior (Shepherd, 1994), language (Banks, 1995; Carlson, 1994; Macphail, 1998), theory of mind (Stuss & Anderson, 2004), the formation of the self (Greenwald & Pratkanis, 1984), cognitive homeostasis (Damasio, 1999), the assessment and monitoring of

[3] In the early 20th century, epiphenomenalism may have served as a healthy reaction to the prevalent mentalism of structuralist, pre-behaviorist psychology, which attempted to explain all operations in terms of conscious processes.

mental functions (Reisberg, 2001), semantic processing (Kouider & Dupoux, 2004), the meaningful interpretation of situations (Roser & Gazzaniga, 2004), and simulations of behavior and perception (Hesslow, 2002).

A recurring idea in recent theories is that phenomenal states somehow integrate neural activities and information-processing structures that would otherwise be independent (see review in Baars, 2002), an idea that goes back at least to Sherrington (1906). This notion, here referred to as the *integration consensus*, has now resurfaced in diverse areas of research (Clark, 2002; Damasio, 1989; Dehaene & Naccache, 2001; Freeman, 1991; Llinas & Ribary, 2001; Ortinski & Meador, 2004; Sergent & Dehaene, 2004; Tononi & Edelman, 1988; Varela, Lachaux, Rodriguez, & Martinerie, 2001; Zeki & Bartels, 1999). Clark (2002), for example, proposed that phenomenal states are necessary for the reason-and-memory–based selection of action, which uses knowledge from different bases, but not for "online," non-memory-based processing that does not require the integration of such kinds of information. Similarly, in Baars's (2002) conscious access hypothesis, phenomenal states allow for the global access of information (e.g., auditory, affective, and visual information). Many of these theories speak of a central information exchange, where dominant information is distributed globally (for a treatment of what processes are dominant, see Kinsbourne, 1996).

## Limitations of the Integration Consensus

Unfortunately, as some of their proponents would admit, most of these theories speak in general terms. Most important, it remains unclear which kinds of information are distributed in this global, conscious manner and which kinds are distributed in a different, perhaps unconscious, manner. Obviously, not all kinds of information are capable of being disseminated globally (e.g., neural activity related to vegetative functions, reflexes, unconscious motor programs, low-level perceptual analyses, etc.) and many kinds can be disseminated and combined with other kinds without phenomenal processing (e.g., as in the ventriloquism effect, see below). Hence, regarding the integration consensus, a critical issue remaining pertains to which kinds of dissemination require phenomenal states and which kinds do not.

## The Task Demands of Penetrable Versus Impenetrable Processes

When are phenomenal states summoned to action? The present, contrastive approach attempts to answer this question by contrasting the task demands of consciously penetrable and consciously impenetrable processes (for related paradigms, see Baars, 1988; Dulany, 1991; Jacoby, 1991; Jacoby, Yonelinas, & Jennings, 1997; for a criticism of this kind of paradigm, see O'Brien & Opie, 1999). This approach contrasts processes that are consciously available (e.g., aspects of pain and hunger) with those nervous processes that, as far as we know, are never consciously available (e.g., the mediation of reflexes and vegetative processes).[4] Assuming that conscious processes accomplish something that unconscious processes cannot, this approach helps identify the role of phenomenal states. Why, for example, is the pupillary reflex wholly unconscious from input to output, but not the act of enduring potential tissue damage for some end (e.g., carrying a scorching plate to the dinner table)?

When answering this question, it is best to abandon all preconceptions and regard both kinds of processes as veritable forms of human action, regardless of how different they may seem in nature. The temptation has always been to a priori demote reflexes to something below that of normal human action and answer the question by claiming that the latter is a real action involving decisions, whereas the former is a vegetative event, but doing so explains nothing, robs reflexes of their sophistication, and more important, robs scientists of an opportunity to appreciate the subtle differences between conscious and unconscious action.

In addition, the difference between the two kinds of processes cannot simply be one of controllability (a more sophisticated version of this hypothesis was espoused by Angell, 1907), for reflexes are controlled, sometimes in highly sophisticated and dynamic ways (e.g., by feedback loops; Shepherd, 1994). In addition, the difference cannot simply be one of complexity because reflexive processes can be highly complex but unconscious, as in the case of motor programs (Grossberg, 1999; Rosenbaum, 2002). Taken by itself, even the pupillary reflex is far from simple. Modulated by both divisions of the autonomic nervous system, it is elicited by conditions as diverse as changes in light level, arousal, and point of focus. Amazingly, regardless of light conditions, both pupils are always matched in diameter. When one eye is covered, the pupil of the other dilates; when it is then uncovered, the pupil of the other constricts. Although the mediation of this behavior occurs unconsciously (indeed, it can be elicited in comatose patients; Klein, 1984), there is a subtle, phenomenal component to the reflex. During dilation, this component is experienced as an increase in brightness; during constriction, it is experienced as a decrease in brightness. However, these phenomenal components occur only after the execution of the reflex.

Evidently, identifying the difference between conscious and unconscious processes proves to be more difficult than what common experience suggests (Chartrand & Bargh, 2002). The solution cannot simply reflect differences in complexity, controllability, or how action-like the nervous events are. Faced with these difficulties, perhaps it is then fair to conclude that conscious processes, unlike reflexes, are consciously controlled, but this obviously provides nothing more than a circular explanation for why the two kinds of processes are different.

An intuitive answer to the question posed above is that, unlike the pupillary reflex, the most adaptive action in response to carrying a painfully hot dish depends on taking several different kinds of information into account (e.g., the cost of the dish and of the food being carried, the extent of tissue damage, the time and effort it would take to replenish the food, etc.). Despite its complexity, such overarching considerations are not made for the pupillary

[4] Unlike the present approach, other approaches stemming from different theoretical concerns contrast the task demands of the same cognitive process when it is novel and presumably consciously mediated and when it is overlearned, automatized, and presumably less consciously mediated (Logan, Taylor, & Etherton, 1999). By contrasting only penetrable and impenetrable processes, a benefit of the present approach is that it diminishes the likelihood of conflating conscious and attentional processes, a recurring problem in accounts concerning the relationships among conscious, automatic, and unconscious processes (Baars, 1997).

reflex. This is consistent with Block's (1995) view that consciousness serves a rational, reflective role (Johnson & Reeder, 1997). A hallmark of rational behavior is its capacity to take various kinds of information into account when planning action. Irrational behavior, on the other hand, seems to operate blindly of such considerations. The answer is also consistent with the integration consensus, in which phenomenal states bring together diverse forms of information.

Thus, in general terms, I propose that the difference between conscious and unconscious processes lies in the kinds of information that have to be taken into account in order to produce adaptive behavior: Whenever the most adaptive response entails considering certain different kinds of information, phenomenal states are called into play. Integrating such diverse kinds of information could be regarded as a task demand not met by unconscious processes. But it should be noted that the kinds of information involved cannot simply comprise visual, haptic, auditory, or olfactory information. As outlined below, several phenomena reveal that diverse kinds of information, including data from different modalities, can be integrated unconsciously. The information transfers requiring conscious processing appear to be distinguished by a criterion that has defied identification (Banks, 1995). Applying the contrastive approach to a special subset of cognitive operations (conscious and unconscious conflicts) reveals this criterion, leading to a more specific distinction between the task demands of conscious and unconscious processes.

## Contrasting Conscious and Unconscious Conflicts

Moving beyond reflexes, why are the informational conflicts in the ventriloquism effect, binocular rivalry, and the McGurk effect (McGurk & MacDonald, 1976) resolved unconsciously but not the conflicts arising, for example, while carrying a heavy load, holding one's breath, or during any other pain-for-gain scenario? To answer this question, I review the task demands of some representative conscious and unconscious conflicts.

### *Unconscious Conflicts*

In the popular ventriloquism effect, a conflict exists between the auditory and visual systems regarding the source of a sound (for recent treatments, see Vroomen & de Gelder, 2003). The auditory system detects a sound originating at one place (e.g., the puppeteer's closed mouth), but the visual system detects motion at another place (e.g., the puppet's mouth). In this situation, an observer perceives the sound as originating from where there is motion (e.g., the puppet's mouth). The observer is unaware of the sensory conflict and of the processes underlying its resolution.

In binocular rivalry (Logothetis & Schall, 1989), an observer is presented with different visual stimuli to each eye (e.g., an image of a house in one eye and of a face in the other). It might seem reasonable that, faced with such stimuli, one would perceive an image combining both objects—a house overlapping a face. Surprisingly, however, an observer experiences seeing only one object at time (a house and then a face), even though both images are always present. At any moment, the observer is unaware of the computational processes leading to this outcome; the conflict and its resolution are unconscious.

In the McGurk effect (McGurk & MacDonald, 1976), a conflict exists between the auditory and visual systems regarding the nature of a phonological stimulus—an observer views a speaker mouthing the phoneme /ga/ but is presented with the auditory stimulus /ba/. Surprisingly, as a result of the sensory conflict, the observer perceives /da/. Again, the observer is unaware of the conflict and is aware only of its perceptual product (/da/). (For a sophisticated variant of this effect, see Green & Miller, 1985.) Another unconscious conflict involves the interaction between the vestibular and visual systems, which is quite noticeable after one stops spinning: Though one is stationary, the visual world continues to move. One is unaware of the vestibular and visual contributions taking part in this effect and is aware only of the products of their interaction.[5]

In summary, phenomena such as the ventriloquism effect, binocular rivalry, and the McGurk effect (McGurk & MacDonald, 1976) are informational conflicts that can be resolved unconsciously. This kind of resolution (i.e., end of conflict) can be conceptualized as a case of unconscious interaction. That is, although information from different sources is brought together to yield a conscious, perceptual resolution, the interactive process can be opaque to awareness. Naturally, unconscious interactions do not imply that one could never be conscious of the individual kinds of information (e.g., the sound of /ba/) forming the components of the interaction; rather, they reveal that some forms of information can interact without phenomenal mediation. At a minimum, these phenomena demonstrate that conscious processing is unnecessary to integrate information from sources as diverse as different modalities. Intermodal cross-talk can occur without it. A list of representative unconscious interactions is presented in Appendix A.

### *Conscious Conflicts*

Clearly not all conflicts can occur and be resolved unconsciously. Returning to the scorching plate scenario, it is clear that one would, in some sense, be aware of something inclining one to drop the dish (related to pain) and of something inclining one to continue carrying it. Terms such as *impulse control*, *inhibition*, and *approach–avoidance* (Miller, 1959) have been used to characterize these situations, but I refrain from using such theoretically laden terms (for research on impulse control, see Baumeister, Heatherton, & Tice, 1994; Mischel, Shoda, & Rodriguez, 1989). For present purposes, it is best to reencounter these quotidian phenomena with the same naïveté and caution with which unconscious conflicts were approached.

Moreover, to identify the primary function of phenomenal states, it is progressive at this stage of understanding to focus on conscious conflicts associated with basic operations such as breathing, drinking, and enduring pain rather than on those associated with higher level phenomena (e.g., complex problem solv-

[5] Whether conflicts lead to fusions (as in the McGurk effect) or not (as in binocular rivalry) may depend on the specific, adaptive properties of the particular perceptual systems involved. For example, because in normal circumstances sound tends to correlate with motion, the visual bias exhibited in the ventriloquism effect is an adaptive strategy. Yet, speculations about the adaptive tendencies of perceptual systems is beyond the scope of this article.

ing, humor, music appreciation, and nostalgia). Such higher level phenomena are more likely to be predicated on (a) extensive learning, (b) cultural influences, (c) intricate interactions among more elemental conscious processes, and (d) adaptations that are less phylogenetically primitive than those of the basic operations of interest—factors whose influence on phenomenal states awaits further empirical and, likely, theoretical developments.

It is a fact of common observation that conscious conflicts are sometimes a source of great mental strife. Interestingly, such internal strife is not manifest in observable behavior, at least not in an obvious manner and not at one moment in time. (Subtle behavioral responses, such as the galvanic skin response, may reflect the internal conflict; Luria, 1932). "At one moment in time" should be emphasized because there are instances in which, over time, observable hedging does occur, as when one moves toward and then away from some goal during conflict. In this article, however, I focus on what occurs during discrete, goal-directed actions (e.g., carrying an object, depressing a lever, opening a box), on the instrumental behaviors that Skinner (1953) characterized as operants.

Despite the internal conflict, expressed behavior is integrated in the sense that one observes a single purposeful act (e.g., someone carrying a hot dish), though the act is simultaneously influenced by multiple inclinations: Pain inclines the dish carrier to drop the dish, while other motives (e.g., perhaps the desire to save food) incline him or her not to. It is only because of our capacity to empathize that we can correctly infer that the dish carrier is experiencing an aversive, conflicted state. This circumstance reflects Chomsky's (1988) brilliant observation that, unlike machines, we humans can be inclined, not just compelled, to act a certain way.[6] Yet, despite our capacity to infer conflict, behavior is far from fractionated because either one or the other action plan is carried out. I now review the features of several classes of conscious conflicts.

The hot plate example is an archetypal case of a conflict involving potential or actual tissue damage. Much has already been said about the dynamics of this phenomenon. It occurs, for example, when one carries a heavy load, runs across the hot desert sand to reach water, stands too close to a bonfire, or practices guitar scales till the fingers bleed. Of theoretical import is the observation that, regardless of the adaptive value of one's action plan, the aversive state that is coupled with the action cannot be voluntarily modulated or turned off (at least not without some difficulty). Although obtaining water is clearly more vital than protecting one's feet, performing the action is nevertheless as aversive as if there were no reward for performing it. Thus, the information-processing structures responsible for the aversive state can be regarded as "affectively encapsulated" from those of other inclinations (Öhman & Mineka, 2001).

At the same time, the behavioral act enticed by the aversive state can be voluntarily controlled and unexpressed for some time. In the hot plate example, one is inclined to drop the dish, but can keep from doing so. Figuratively speaking, one is incapable of controlling the affective dynamics of the experience but is capable of controlling the motor system, at least to a certain extent. If the tissue damage is too great, it seems that the motor system escapes one's control and behavior becomes quasi-reflexive (e.g., the hot dish of food is dropped). This is considered to be the behavioral component of the pain response (Drzezga et al., 2001).

Conflicts involving consummatory behavior form another class of conscious conflict. These occur, for example, when one is inclined to consume food, but for other reasons (e.g., fear of tissue damage), one is inclined not to. In our evolutionary history, this may have occurred when a coveted food source was violently guarded by an animal (e.g., a fresh kill protected by a leopard) or located in a precarious environment (e.g., crabs in ice-cold water). In modern times, the conflict is perhaps more common as the anguish arising from self-imposed food restrictions, as in fast-related dieting. One consciously desires food but has negative affect toward consuming it. To the detriment of extreme dieters, the negative affect is hard (or impossible) to voluntarily quell. As in the tissue damage example, the nature or intensity of the affective state cannot be controlled (Öhman & Mineka, 2001), but the motor system can be controlled to some extent. There is probably a threshold at which consummatory behavior becomes quasi-reflexive, but this reflexive component is beyond the purview of this article (for an account of how it may operate in drug addiction, see Baker, Piper, McCarthy, Majeskie, & Fiore, 2004).

Similar classes of conflict involve air intake, water intake, sleep onset, temperature regulation, and various elimination behaviors. For example, if compelled to hold one's breath underwater, as when trapped under ice, one feels the urge to breathe (for not doing so leads to death) and the urge to refrain from doing so (for inhaling water leads to drowning). Although the urge to breathe is adaptive in most circumstances, the negative affect it elicits in this scenario can be fatal. Figuratively speaking, the affectively encapsulated process engendering this urge is incapable of knowing or being influenced by the fact that inhaling in such a situation is harmful. One can readily imagine analogous conflicts involving the need for water (e.g., when the only water available is painfully cold), the need for sleep (e.g., when being preyed on or driving), the need for warmth (when hunting in cold weather), and the needs related to various elimination behaviors.

It should be clarified that conscious conflicts are fundamentally different from mere doubts or dilemmas, as when one ruminates whether one should do *x* or *y* (e.g., vacation in Granada or Hawaii). In contrast to such kinds of thinking, conscious conflicts are active and, in terms of phenomenology, "hot" (Metcalfe & Mischel, 1999). The tugging and pulling from their competing inclinations obtrusively creep up on awareness and seem to be beyond one's mental control. They seem, rather, to be visceral and automatic (Metcalfe & Mischel, 1999). For example, one can easily choose to forget the allure of Hawaii after deciding to vacation in Granada, but one has no such control over the inclinations arising after one has decided to endure breathlessness or tissue damage for some end, conflicts that, in a sense, cannot be postponed or ignored. In addition, one may face a dilemma regarding which foods to eat, but this is altogether different, both in degree and in kind, from the powerful states one experiences during pain, breathlessness, starvation, or the suppression of elimination behaviors. In short, unlike doubts or dilemmas, one has no direct cognitive control over how and when these conflicts occur.

One can readily bring to mind other kinds of mental strife, but these classes are sufficient to illustrate the difference between

[6] Chomsky (personal communication, October 14, 2003) attributes this interesting observation to Descartes.

conscious and unconscious conflicts. I refer to the former type of conflicts as cases of *conscious interaction,* for one is aware of the conflicting components (e.g., pain and hunger) that are brought together to influence action. Interestingly, however, one is unaware of the computational products of conscious interaction, which, should they exist, are observable only in the form of expressed behavior. In other words, one is unconscious of the representations reflecting the resolution of the conflict (if such representations exist). Conversely, in unconscious interactions, one is unaware of the components but aware of the products, as when one is unaware of the veridical nature of the auditory and visual stimuli in the McGurk effect (McGurk & MacDonald, 1976) but is aware of the resolution (/da/). Thus, from a stages-of-processing perspective, one is unconscious of a substantial amount of processing occurring prior to phenomenal states and of a substantial amount following them (e.g., the representations guiding observed behavior). This is consistent with the view that consciousness reflects intermediary processing (Jackendoff, 1990; Lashley, 1956).

### *The Difference Between Conscious and Unconscious Interactions*

As mentioned above, it is no longer useful to claim that conscious processes are simply more complex, controllable, planned, decision-like, or action-like than unconscious ones. Nor is it useful to propose, as suggested by the integration hypothesis, that unconscious processes are incapable of integrating different kinds of information, for the observations above suggest that various kinds of interactions can occur unconsciously. So why can interactions occur unconsciously for the ventriloquism effect, binocular rivalry, the McGurk effect (McGurk & MacDonald, 1976), and the other phenomena listed in Appendix A but not for conflicts involving tissue damage, air intake, or consummatory behavior? As explained in the theory presented below, it is because the latter conflicts require interactions among information-processing structures having different, high-level concerns (Damasio, 1999; Frijda, 1986), an anthropomorphic term that warrants a precise definition.

In physiology, each organ of the body is construed as a collection of cells or tissues with a common purpose or concern. Thus, the human organism as a whole possesses multiple concerns, only a small portion of which are related to phenomenal processes in any way whatsoever. One can consider some of the incessant yet unconscious concerns of osmoregulation, thermoregulation, circulation, respiration, digestion, and immunity. The key to unraveling the function of phenomenal states is in identifying what distinguishes concerns that are phenomenally available from those that are not, a problem that is addressed below. For now, it is progressive to conceptualize large-scale brain systems in terms of concerns rather than simply in terms of the sensory systems with which they are furnished, which has been the traditional approach to identifying mental faculties (cf. Barsalou, 1999).

Returning to ventriloquism, it seems that auditory and visual information can interact unconsciously within a higher level system concerned not simply with what the ear heard or what the eye saw, but with where the sound originated. In binocular rivalry, the outputs of multiple modules are culled to determine, not what the left or right eye saw, but the nature of the object before one. In the McGurk effect (McGurk & MacDonald, 1976), the question addressed by multiple modules is not "What did I hear?" or "What did I see?" but something akin to "What was said?"[7] In essence, these cases of unconscious interaction seem to be concerned with a broader issue, something to the effect of "What happened and where did it happen?" For this concern, it seems that auditory, visual, and other kinds of information (e.g., vestibular, olfactory, and information from perceptual memories) can interact unconsciously to reach a conclusion.

This conceptualization of unconscious interaction leads to the view that, although there may be a countless number of informationally encapsulated modules (Fodor, 1983) that are responsible for specialized tasks (e.g., motion detection, color detection, auditory analysis; Zeki & Bartels, 1999), phenomenal states may not represent (and are not modulated by) the individual activities and conclusions of each of these modules. Instead, what is phenomenally represented seems to be above the level of the output of individual modules (Marcel, 1993) and reflects, rather, the combined outputs of multiple modules (Ernst & Bülthoff, 2004). Of all the unconscious interactions listed in Appendix A, this is most dramatically illustrated in the McGurk effect (McGurk & MacDonald, 1976), where the conscious percept (e.g., /da/) is determined by the successful sensory (and unconscious) processing of the auditory (e.g., /ga/) and visual (e.g., /ba/) stimuli. Likewise, the ventriloquism effect is in part predicated on the successful processing of auditory information (to perceive the puppeteer's speech) and visual information (to attribute the speech to the puppet's mouth). Thus, I propose that phenomenal states represent, not the outputs of individual modules, but the products of *supramodules*: information-processing structures composed of multiple modules and defined in terms of their concerns rather than in terms of their sensory afference.

Just as modules have been traditionally characterized as devoted to specialized tasks, supramodules can be characterized as devoted to higher level tasks, taking as their inputs the outputs of lower-level, modular processes. Without invoking phenomenal states, supramodules can cull lower level outputs to carry out functions beyond those played by modules. Observations suggest that one can be aware of the products of these higher level functions and not of the simpler conclusions on which they are based. In contrast, it seems that there cannot be unconscious interactions for outputs defined by certain higher level concerns. In pain-for-gain scenarios, for example, an adaptive response must take into account information beyond "What did the ear hear or the eye see?" and even beyond "What happened and where did it happen?"

## Beyond Modularity: Supramodular Response Systems

The idea of systems above the level of the module is not new (Bindra, 1974; Gallistel, 1980; Metcalfe & Mischel, 1999; Milner & Goodale, 1995; Minsky, 1985; Strack & Deutsch, 2004; Ungerleider & Mishkin, 1982). Most influentially, Plato, Aristotle, and Freud each took the sword to the psyche and divided it into sophisticated, quasi-independent agents (e.g., Freud's id, ego, and superego). In these conceptual frameworks, each mental agent

[7] Of course this is a gross simplification of the problem, for the nature of the phenomenal speech percept is a matter of contention (see review in Remez, 1994).

doggedly pursues its own agenda and can come into conflict with those of other agents—the id wants to eat cake, but the ego wants to lose weight. It is important to note that, for each agent to possess such knowledge about the present state of affairs (e.g., knowing that there is a chocolate cake before one), each must receive conclusions from multiple information-processing structures. These historic agents are, thus, supramodular in nature.

More recently, Bindra (1974, 1978), being interested in the multiple aspects of a single behavioral response, proposed that there is a multimodal, high-level system devoted to physically negotiating instrumental actions with the environment. Consistent with classic research (Tolman, 1948) showing that the instrumental competence needed for a task (e.g., for navigating a maze) is predicated on forms of knowledge and goals that are different in nature from those of incentive learning, Bindra held this system to be responsible for the instrumental aspect of a behavioral response. This system is involved with navigating through a space, approaching the location of objects, grabbing objects, pressing levers, manipulating objects, and other kinds of instrumental acts. From this perspective, the system treats and represents all objects in the same manner regardless of the organism's motivational state (Bindra, 1974). For example, stimuli such as food and water are negotiated in roughly the same manner whether the organism is hungry, thirsty, or sated (Lorenz, 1963). Phenomenally, it is thus a "cool" (vs. a "hot") system (Metcalfe & Mischel, 1999), for it is not hedonic or emotional in nature.

### *The Instrumental Response System*

I propose that the multimodal outputs that are unconsciously integrated in phenomena such as the ventriloquism effect, binocular rivalry, and the McGurk effect are nested in a supramodular system similar to Bindra's (1974) instrumental system. As mentioned above, this cool, multimodal system is concerned with discovering what can best be characterized as "What happened?", "What is going on?", and "How should an instrumental goal be carried out?"[8] More precisely, and borrowing from Bindra (1974), this system's goal is to integrate information bearing on how the skeletomotor system should physically interact with the world when carrying out instrumental action plans (e.g., navigating through a jungle, using weapons, orienting toward the source of a sound, pressing a button). I refer to this as the *instrumental response system*. In the present framework, this is one of several supramodular response systems.[9]

Apart from the multiple unconscious interactions occurring among primary sensory modules (e.g., for processing visual motion, shape, and color perception; Bernstein & Robertson, 1998; Ernst & Bülthoff, 2004; Zeki & Bartels, 1999), neuropsychological evidence for the existence of such a system stems from research on areas of sensory integration that can influence action (see review in Stein, Wallace, & Meredith, 1995). Such unconscious interactions are best exemplified by the superior and inferior colliculi in the tectum of the midbrain (but see also Milner & Goodale, 1995). These structures integrate information from multiple modalities to localize stimuli and initiate whole-body reflexes toward them, though processing in these structures is believed to be involuntary and unconscious (Curtis & D'Esposito, 2003; Dorris, Pare, & Munoz, 1997).

With respect to phenomenal experience, the instrumental system represents, for example, what it is like when an event occurs on the left or on the right, an object should be held with a power grip or a precision grip, something is above or below something else, or something should be drawn with straight or curved lines. It allows one to handle food, move it around, or even throw it, should it be used as a projectile. In gross terms, all of these actions would be performed in roughly the same manner regardless of whether one is starved, sated, angry, or thirsty, for how the instrumental system modulates phenomenal experience is not modulated by needs or drives. Instead, it is concerned with how a given instrumental action should be carried in the event that it is prompted.

This multimodal system enacts instrumental goals (e.g., opening a door), many of which are acquired from a long learning history (Bindra, 1974, 1978). In addition to operant forms of instrumental learning (Skinner, 1953; Thorndike, 1911), the system is capable of vicarious and latent learning (i.e., learning without reward or punishment; Tolman, 1948). As Tolman demonstrated, the learning of action–effect contingencies can be learned without reinforcement or punishment. In a cool manner and without invoking valence or affect, the instrumental system can predict and mentally represent the instrumental consequences of its action (e.g., what the world looks like when a dish is dropped, a table is reached, a box is opened). Thus, the system is highly predictive in nature (Berthoz, 2002; Frith et al., 2000; Llinas, 2002).

The operating principles of the directed actions of this system are perhaps best understood in terms of the historical notion of ideomotor processing. Introduced by Lotze (1852) and Harless (1861) and eloquently popularized by James (1890) in his treatment of voluntary behavior, ideomotor theory states that the mental image of an instrumental action tends to lead to the execution of that action. James (1890, pp. 520–524) famously said that "thinking is for doing," meaning that the mere thoughts of actions produce impulses that, if not curbed or controlled by "acts of express fiat" (i.e., exercise of veto) result in the performance of those imagined actions. He added that this was how instrumental actions are learned and generated: The image of the sensorial effects of an action leads to the corresponding action—effortlessly and without any knowledge of the motor programs involved. (For

[8] This supramodular system should not be confused with the "what" visual pathway proposed by Ungerleider and Mishkin (1982) or the conscious "perception" pathway proposed by Milner and Goodale (1995). Although it is tempting to incorporate findings that demonstrate dissociations between action and perception into the present framework (for recent evidence, see Wraga, Creem, & Proffitt, 2000), at this time such findings remain too controversial (see Franz, Gegenfurtner, Bülthoff, & Fahle, 2000; Jeannerod, 2003) for a theory about something as intangible and recondite as phenomenal states. One strength of the present framework is that it is based on such uncontroversial phenomena as the McGurk (McGurk & MacDonald, 1976) and ventriloquism effects.

[9] From this perspective, perhaps it is no longer useful to believe in conscious, unimodal sensory experiences (such as that of a pure tone or of the sound of the phoneme /da/), for that which we are aware of stems from the workings of multiple sensory systems. That a given phenomenal visual or auditory percept is not the result of unimodal processing is not new to perceptual psychologists (see review in Ernst & Bülthoff, 2004; Remez, Rubin, Berns, Pardo, & Lang, 1994).

current accounts, see Hommel, Müsseler, Aschersleben, & Prinz, 2001; Prinz, 2003.)

Phenomenally, the goals of this system are subjectively experienced as instrumental "wants," as in what it is like to intend to press a button, rearrange the placement of objects, move a limb in a circular motion, or remain motionless. As explained by ideomotor approaches (Hommel et al., 2001), a unique feature of this system is that when enacting its goals it has privileged access to the skeletal muscle system and is thus the dominant system with respect to immediate skeletomotor action. Thus, unlike affective states, which cannot be modulated directly (Öhman & Mineka, 2001), instrumental goals can be implemented instantaneously. It should be reiterated that this system's goals are cool and consist only of instrumental end states (e.g., a door opened, a field traversed, a button depressed).

From this standpoint, when starved and faced with food that is trapped under a heavy slab of ice, for example, it could be said that (at least instrumentally speaking) one "wants" to lift the heavy ice and can readily "will" the initiation of the act. In contrast, the intuitive (and highly inferential) interpretation that one simply "wants food" in such a situation obscures the fact that, in terms of immediate action, an instrumental intention is necessary to remove the obstacle. Of course one would prefer to obtain food in easier ways, but in such a scenario and in terms of immediate experience, lifting the heavy ice is the current goal of the instrumental system and the desired plan of action. Thus, in contrast to traditional operant approaches (Skinner, 1953), performing an instrumental act for an incentive simultaneously leads to different kinds of learning (instrumental and incentive) that occur in parallel (Bindra, 1974; Öhman & Mineka, 2001; Tolman, 1948). In the present example, heavy ice may in the future serve as an appetitive stimulus because of hot, incentive learning (Bindra, 1978), and the act of lifting the heavy ice may become more efficient because of cool, instrumental learning.

Accordingly, food "looks" and "sounds" the same whether one is hungry or sated, at least in terms of instrumental action. For example, perceptually, a candy cane appears the same before and after one learns that it is edible. At some level, skeletomotor actions toward the object would be the same whether one thinks that it is made of sugar or plastic. Some neuropsychological observations are consistent with this standpoint. For instance, it has been demonstrated that, in some cases, the reinforcement contingencies of a stimulus do not modulate the neural activity underlying the sensory processing of that stimulus (Rolls, Judge, & Sanghera, 1977). In regard to vision and hunger, Rolls and Treves (1998) concluded, "It would not be adaptive, for example, to become blind to the sight of food after we have eaten it to satiety" (p. 144), meaning that it is adaptive for there to be an independence between information for instrumental and for incentive actions. Other evidence stems from addiction research, in which dissociations are reported to exist between instrumental action and affective states. For example, though resembling "wanting" because of their repetitive and persistent nature, some addiction-related behaviors are actually unaccompanied by "liking," that is, by the congruent subjective drives (Baker et al., 2004; Berridge & Robinson, 1995).

Of course, this does not mean that attention is uninfluenced by motivational states (for a recent treatment, see LaBar et al., 2001) or that perception is uninfluenced by values, needs, and wants. As espoused in "new look" theories (Bruner & Goodman, 1947), motivational states play a large role in attention and perception. The present claim is only that, at the level of gross operant behavior, instrumental considerations are unaffected by incentive variables. The acts of navigating through a maze, pressing a lever, or drawing a candy cane, for example, would be carried out in roughly the same manner regardless of the nature of environmental contingencies (e.g., reward vs. punishment; Skinner, 1953).

In summary, I hypothesize that there is a cool, supramodular response system that is ultimately in the service of instrumental action. It can unconsciously integrate modular outputs from diverse sources to have its conclusions, or response tendencies, represented in the phenomenal field.[10] However, this alone is insufficient to create adaptive behavior. Such behavior must also take into account the outputs of the incentive response systems.

### *Incentive Response Systems*

Based on Bindra's (1974, 1976) consummatory and regulatory aspects of the behavioral response, the incentive response systems are involved with what have traditionally been designated as basic drives, needs, and motivations (B. A. Campbell & Misanin, 1969). Stimuli related to these systems have been referred to as "affective," "hedonic," "emotional," or "incentive" (Bindra, 1974). Fundamentally, incentive systems are concerned with whether certain actions should take place (and the extent to which they should take place) and not concerned so much with how they should take place instrumentally. Should the human organism pursue food, attack a foe, continue to expend energy to climb a hill in order to reach water, or should it just stay put? From this standpoint, the experiential and behavioral differences resulting from hunger, thirst, breathlessness, and muscle fatigue are due to the activities of these hot systems.

Should one approach a flame or move away from it, carry the hot dish across a room or drop it? As in many other everyday scenarios, the answer depends on many factors, including the extent of physical harm involved and the payoff of withstanding such harm. During these situations, one experiences what it is like to have urges, inclinations, desires, and tendencies. As with the instrumental system, incentive systems can unconsciously integrate modular outputs from diverse sources to address their concerns. One is conscious of the tendencies (e.g., urges and cravings) of these systems but not necessarily of the factors engendering such tendencies (Baker et al., 2004; Nisbett & Wilson, 1977). But unlike the instrumental system, which is the only one of its kind, there are multiple classes of incentive systems, each having its own agenda and response tendencies represented phenomenally.

Consistent with this view is the idea that emotional systems (e.g., for fear, aggression, and reproduction) evolved independently and are modularized in the brain with partially independent learning histories (B. A. Campbell & Misanin, 1969; Carver, 2004;

[10] *Phenomenal field* is a figurative and commonly used term for one's conscious state at one time. The term is helpful because it suggests that the state, as a field, is not static but dynamic and influenced by many variables. It is a matter of debate whether information such as response-system outputs actually constitute the field or modulate it, but this subtle distinction is irrelevant for present purposes. For a treatment concerning whether the field is componential or unitary, see Searle (2000).

LeDoux, 2000; Olsson & Phelps, 2004; Öhman & Mineka, 2001; Tranel & Damasio, 1985, 1993). Regarding emotional systems' modularization, it has long been known that each system functions quasi-independently and has unique operating principles (e.g., involving idiosyncratic interactions with different stimuli and hormonal states); hence, there is no single, uniform, generalized "drive state" that is the same for different incentives (e.g., for hunger or thirst; B. A. Campbell & Misanin, 1969).

For example, fear conditioning is believed to be mediated in part by modularized nuclei in the amygdala of the midbrain that receive polysensory information from afferent pathways that are different from those feeding cortical loci such as Visual Area 1 of the occipital lobe (Lavond, Kim, & Thompson, 1993; LeDoux, 1996; Olsson & Phelps, 2004). This arrangement exemplifies how information-processing structures can integrate similar, albeit diverse, kinds of information to address different concerns: Nuclei in the amygdala process polysensory information to address emotional concerns, whereas the visual cortex and other structures do so to address different concerns. This process occurs roughly in parallel (for adaptive reasons, the amygdalar pathway is slightly faster; LeDoux, 1996).

It is the task of future investigation to identify the number and nature of all the incentive systems. By definition, the systems will be fewer in number than modules, for modules are subsumed by them. At this stage of theoretical development, I consider only the basic, uncontroversial classes of incentive systems (B. A. Campbell & Misanin, 1969; Dempsey, 1951). These systems are described in Appendix B.

For example, the tissue-damage system[11] is inflexibly concerned with the avoidance of tissue damage. At times, this multimodal system can enact its agenda via skeletal muscle (e.g., automatic forms of blinking, coughing, postural shifting, pruritus-induced scratching, and various forms of automatic pain withdrawal). Like other incentive systems, it is capable of incentive learning via Pavlovian conditioning and observational learning (Dickinson & Balleine, 1995; Lavond et al., 1993; Olsson & Phelps, 2004). One can appreciate its adaptive value in curbing other response systems (e.g., the instrumental system) by considering the health tolls that arise when this system malfunctions or is absent, as in disorders related to congenital insensitivity to pain (McMurray, 1950). In such potentially fatal disorders, sensory perception (e.g., for temperature, touch, and pressure) is normal, but there are selective deficits in pain perception and in the associated fear responses (see review in Nagasako, Oaklander, & Dworkin, 2003).

Likewise, the air-intake system is inflexibly concerned with breathing, regardless of the cost of doing so, and can enact its agenda by automatically contracting the diaphragm. The food-intake system is inflexibly concerned with consuming (nonnauseating[12]) food when food deprived (and not doing so when sated), and the water-intake system is concerned with ingesting water when water deprived (and not doing so when sated). These systems can also enact some of their goals via skeletal muscle, as in licking, chewing, swallowing, and other behaviors that can occur automatically once the incentive stimulus activates the appropriate receptors (Bindra, 1974; Kern, Jaredeh, Arndorfer, & Shaker, 2001).

As with all response systems, the incentive systems are unintelligent in the sense that they are incapable of taking other kinds of information (e.g., information generated by other systems) into account. For example, when hungry, the food-intake system desires all kinds of tasty foods, including those that are known by the person to be fattening, unhealthy, or even poisonous. Likewise, the tissue-damage system will protest damage even when there are no means by which to prevent the damage (e.g., one is trapped in a noxious environment) or when the action engendering the damage is life saving. In this sense, response systems operate as traditional modules, but unlike modules, they comprise information from diverse sources, and their outputs are always phenomenally available.

Focusing only on the basic classes of incentive systems provides the present framework with a broad explanatory range while keeping it tractable and falsifiable. At this stage of theory development, it is counterproductive to consider whether there are still higher level, encapsulated incentive systems for, say, reproduction, affiliation, affection, aggression, or exploratory behavior. Instead, to identify the necessary function of phenomenal states, it is more important to examine the hypothesis that, without these states, the outputs of these basic kinds of systems would be incapable of cross-talking and collectively influencing action.

## Supramodular Interaction Theory

Supramodular interaction theory (SIT) is presented schematically in Figure 1. In the figure, traditional, Fodorian modules operate within a few multimodal, supramodular response systems, each defined by its high-level concern. Response System 1 is the instrumental system, concerned with how the organism should physically interact with the world and carry out instrumental goals; Response System 2 is an incentive system concerned with whether the organism should approach a stimulus that causes tissue damage. The fundamental hypothesis of the model is that the essential function of phenomenal states is to permit interactions among response-system outputs and that these states are required for all such interactions. Without them, the outputs from the different systems would be encapsulated and incapable of collectively influencing action. Thus, these states are necessary, though certainly not sufficient, for interactions to occur among response-system outputs. As illustrated in Figure 1, each system modulates a different aspect of the phenomenal field (e.g., the phenomenology of pain vs. hunger, thirst vs. breathlessness, an object above vs. one below, etc.).

### *Predicting Consciousness: The PRISM Principle*

As mentioned above, it has proven to be helpful to define and categorize the various organs and tissues of the human organism in

[11] Although in the singular for simplicity (and to facilitate and simplify the generation of falsifiable hypotheses), each incentive *system* actually refers to a class (or family) of systems. In the case of tissue damage, for example, it is unlikely that a single system underlies pain from noxious chemical, thermal, or mechanical stimuli, or pain from muscle fatigue. More obviously, it is unfortunately the case that pains of different kinds can involve conscious interactions. For example, when one subjectively experiences pruritus and muscle fatigue simultaneously, the systems giving rise to these subjective states are evidently not interacting unconsciously.

[12] Nausea-induced food aversion is construed here as a form of hot, incentive learning on the part of the food-intake system.

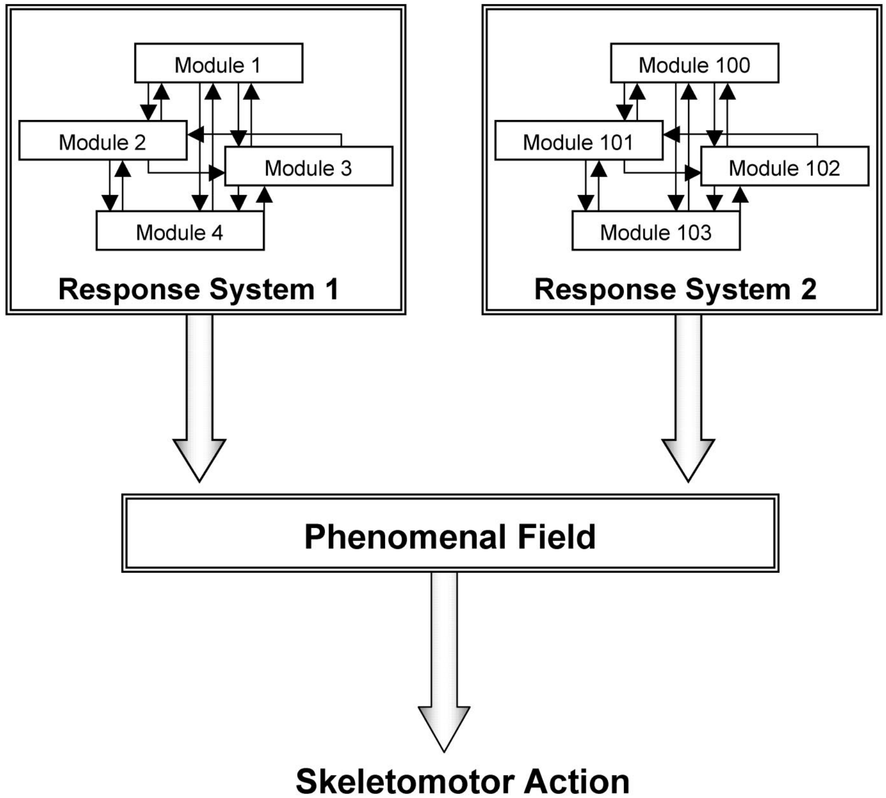


*Figure 1.* Supramodular interaction theory: Fodorian modules operate within a few multimodal, supramodular response systems, each defined by its concern. Response System 1 is the instrumental system, concerned with how the organism should physically interact with the world. Response System 2 is an incentive system concerned, for example, with whether the organism should approach or avoid a stimulus. The outputs of the response systems can interact only in the phenomenal field, and they modulate a different aspect of phenomenal experience.

terms of their concerns or purposes. For example, the kidney and heart have different concerns, which at times can interact and are even capable of lethal conflict (as in some forms of congestive heart failure), but most of these concerns and conflicts never enter awareness. As in the rest of the body, the human nervous system possesses various quasi-independent systems defined by concerns. For example, outside of the present framework (which focuses only on high-level concerns), the traditional visual and auditory systems could also be said to have concerns (e.g., regarding the nature of the inputs to the eye and to the ear, respectively). Many of these systems can interact unconsciously, but the examples above reveal that one can be unaware of processing at certain primary levels but be aware of processing at higher levels (Jackendoff, 1990; Marcel, 1993), levels pertaining to broader concerns, as illustrated by the outputs of the instrumental system.

What distinguishes conscious from unconscious concerns? In other words, what renders a nervous (or bodily) system a phenomenally available supramodular response system? Without this answer, SIT fails to predict, a priori, exactly which kinds of interactions involve phenomenal states. Again, it cannot be the case that phenomenal concerns are simply more complex, controllable, planned, decision-like, or action-like than unconscious ones. Faced with this, one may then propose that, unlike unconscious concerns, phenomenal concerns are those that involve memory or top-down processing (e.g., Clark, 2002; Koch, 2004), but this is inconsistent with the fact that top-down processing and at least some forms of memory are immanent in the unconscious processes that give rise to various perceptions and illusions, including those involving depth perception, object perception (Hochberg, 1998), and the McGurk effect (Green & Miller, 1985). Conversely, one can readily consider conscious conflicts that tax little if any memory whatsoever (e.g., enduring extreme temperatures, removing an impaled thorn, or resisting the weight of a falling object).

Interestingly, when applied to response systems, the contrastive approach reveals that what distinguishes conscious from unconscious concerns reflects not the nature of sensory afference, predictive capacity, or memory demands involved, but rather the nature of the effectors involved: A common property of the response tendencies presented in Appendix B is that they can all be realized in terms of skeletal muscle plans. For example, expressing (or suppressing) inhaling, coughing, blinking, pruritus-induced scratching, pain withdrawal, licking, swallowing, micturating, and defecating all involve skeletal muscle plans. Conversely, no skeletal muscle plans are directly involved in the actions of consciously impenetrable processes such as the pupillary reflex, peristalsis, stomach action, bronchial dilation, and vasoconstriction (which all involve smooth muscle) and the regulation of heart rate (which involves cardiac muscle).

On the basis of observations such as these, SIT proposes that, unlike other bodily processes (e.g., the pupillary reflex) and systems (e.g., cardiovascular and immune systems), supramodular response systems are unique in that their outputs may potentially conflict with each other regarding skeletal muscle plans. By extension, a concern is a conscious concern if its tendencies could ever conflict with skeletal muscle plans. In short form, this notion is captured by the principle of parallel responses into skeletal muscle (PRISM). Fortuitously, the acronym happens to be conceptually related to the principle, for just as a prism can combine different colors to yield a single hue, phenomenal states cull simultaneously activated response tendencies to yield a single, adaptive skeletomotor action.

It is more than surprising that the involvement of something as noncognitive as skeletal muscle predicts whether a nervous process will involve phenomenal states. Then again, one must consider that one of the most elegant adages in the study of nervous activity is that the function of the nervous system is to activate the right (skeletal) muscles at the right time. It has been known since at least the 19th century that, though often functioning unconsciously (as in the frequent actions of blinking, breathing, and postural shifting), skeletal muscle is the only effector that can be controlled directly via conscious processes, but why this is so has never been addressed. As an explanatory framework, SIT introduces a systematic reinterpretation of this age-old fact: Skeletomotor actions are at times "consciously mediated" because they are directed by multiple, encapsulated systems that, when in conflict, require phenomenal states to yield adaptive action.[13]

### General Hypotheses

Within SIT, the PRISM principle specifies what renders a system a supramodular response system, and, more generally, it is unique in its ability to successfully distinguish conscious from unconscious processes. Accordingly, beyond interactions within the nervous system, unconscious conflicts between, for example, the heart and the liver do not involve skeletal muscle plans. In addition, regarding complex processes such as digestion and excretion, one is conscious of only those phases of the processes that require coordination with skeletal muscle plans (e.g., chewing or micturating). Although identifying and describing still higher level responses systems is beyond the presently intended purview of SIT, the PRISM principle correctly predicts that certain aspects of the expression (or suppression) of emotions (e.g., aggression, affection, disgust), reproductive behaviors, parental care, and addiction-related behaviors should be coupled with phenomenal states, for the action tendencies of such processes may compromise skeletal muscle plans.

Conversely, I hypothesize that, unlike the activities of the immune and cardiovascular systems, and strongly echoing James's (1890) notion that thinking is for doing and Sechenov's (1863) provocative idea that conscious thoughts should be regarded as inhibited actions, the kinds of information that are capable of modulating the phenomenal field are also capable of influencing skeletomotor plans (for related views, see Jeannerod, 2003; Sperry, 1952). For example, experiencing "yellow" may not dramatically contribute to skeletomotor actions in one scenario (e.g., while gazing at the sun) but it can certainly influence actions in other contexts (e.g., when selecting ripened fruits).[14] More specifically, just as there is a behavioral component to pain (Drzezga et al., 2001), it is predicted that there is a behavioral, skeletomotor plan associated with each goal participating in a given conscious conflict and that, in such conflicts, the skeletomotor tendencies associated with one goal are incompatible with those of the other goal. For example, when carrying a hot dish, the skeletomotor goal of holding the dish is incompatible with that of dropping it. In more general terms, one can propose that a plan can be mediated unconsciously insofar as it may not potentially conflict with skeletal muscle plans (e.g., of any response system).

One can further speculate that, in evolutionary terms, conscious processes evolved to mediate large-scale skeletomotor conflicts caused by structures in the brain with different agendas, behavioral tendencies, and phylogenetic origins (LeDoux, 1996; Luria, 1932; Olsson & Phelps, 2004). Logistically, phenomenal states could be considered as one of the mechanisms solving the problem of integrating processes in a largely parallel brain that must satisfy the demands of a skeletomotor system that can often express actions and goals only one at a time (Lashley, 1951; Mandler, 1997; Wundt, 1900).

Because of the variety and quantity of instrumental goals (e.g., contracting a limb, lifting an object, playing the piano), conflicts often exist between the instrumental system and an incentive system, but not always, as when there is conflict between incentive systems in which the instrumental system plays a minor role, as when thirsty and drinking painfully cold water (a conflict mainly between the water-intake and tissue-damage systems). The salient dominance of the instrumental system on skeletal muscle explains in part why this kind of muscle has historically been referred to as *voluntary muscle*, an inaccurate description that, as mentioned

[13] It should be emphasized that there is nothing intrinsically special about skeletal muscle that causes it to be related to phenomenality. Conscious concerns are distinguished from unconscious ones not simply because they involve skeletal muscle, but because they involve skeletal muscle in a particular manner, in which encapsulated systems vie to express their respective skeletomotor plans.

[14] If one is aware only of those things that may interfere with skeletomotor plans, then why is one aware of the events portrayed in films or novels, even though these events do not elicit action? Simulacra such as films and novels have been constructed to incite attentional, affective, and other kinds of processes for only an infinitesimally recent fraction of human history. Although beyond the present scope of SIT, these higher level phenomena are actually consistent with the basis of the theory. Stimuli such as horror films succeed in part because they activate inflexible, encapsulated systems that, at some level, are incapable of knowing that what is occurring is not real. For most of our natural history, such activation was clearly adaptive: When observing someone approaching with a weapon, it was beneficial to activate response tendencies. In addition, it is important to distinguish the primary role of evolutionary products from their secondary, potentially "spandrel-like" roles (Gould, 1977; Mayr, 2001). For example, one could argue that color perception evolved for selecting fruits and detecting camouflaged prey, although no one would argue that color perception could also be used to appreciate a Mondrian. One can appreciate the color harmony of a Mondrian in part because it involves the kinds of stimuli that are of adaptive significance in another context. In Aristotelian terms, SIT concerns the functional, final cause of phenomenal states (cf. Killeen, 2001).

above, disregards the fact that skeletal muscle is often controlled involuntarily (N. A. Campbell, 1993), as in blinking, breathing, and in some of the other actions described in Appendix B.

Why the instrumental system seems to have temporally privileged access to skeletal muscle is beyond the scope of SIT and is perhaps best answered by research in evolutionary biology (but see Knuf, Aschersleben, & Prinz, 2001). Moreover, what causes one to perceive an action as being voluntary and self-generated is a complicated issue beyond the scope of SIT (see Wegner, 2002). Nevertheless, it is interesting to note that both intuition and prevalent historical perspectives (Luria, 1932) have construed cool, instrumental actions as struggling to counteract or inhibit[15] the forces of dominant, primitive impulses arising from phylogenetically older parts of the brain. However, according to SIT, a more informative, albeit less intuitive, view is that primitive impulses (e.g., the response tendencies of incentive systems) are actually trying to rein in the often dominant instrumental system, which can select dangerous goals such as touching noxious objects, traversing hot sand, and not breathing. In this framework, James's (1890) "acts of express fiat" refer, not to the actions of a pontifical homunculus but to the agendas of multiple response systems.

### *Chronic Engagement Versus Supervision*

As outlined by PRISM, phenomenal states are associated with outputs that may conflict with the tendencies of other response systems. Thus, as is incontrovertibly evident in common experience, the outputs from response systems incessantly modulate the phenomenal field, regardless of whether there is intersystem conflict. For example, the food-intake system modulates the field when both hungry and sated; and, most obviously, the instrumental system provides the field with representations of one's surroundings regardless of current skeletomotor plans. There is thus chronic engagement among outputs, assuring that no resources, time, or "intelligent homunculus" is required to decide which outputs should participate in the field at a given time. As with many phylogenetic adaptations, such intelligence is embedded in the inherent structure of the apparatus (Simpson, 1949).

Although one could easily imagine more efficient arrangements that invoke phenomenal states only under conditions of conflict, chronic engagement happens to be a rather parsimonious and, in some sense, efficient evolutionary solution to the problem of intersystem interaction. Just as traffic lights, pool filters, and ball-return machines at bowling alleys operate and expend energy continuously (regardless of whether their function is presently needed), chronic engagement is "efficiently inefficient" in the sense that it does not require additional mechanisms to determine whether channels of cross-talk should be open or closed. (In addition, not requiring a supervisory, decision-making component adds to SIT's parsimony; Kimberg, D'Esposito, & Farah, 1997.) Such deceptively inefficient solutions can be observed in biological functions outside the nervous system, as in most biological filters (e.g., the kidneys) that continuously filter a substrate regardless of the status of the substrate.

Chronic engagement reveals the often mentioned monitoring role of the phenomenal field (e.g., Angell, 1907; Norman & Shallice, 1980), but it is misleading to characterize the field as merely supervising the outputs of response systems. Its function is not to observe outputs but to allow continuous interactions among them. Hence, perhaps it is better to compare the phenomenal field, not with a surveillance system, but with a senate, in which representatives from different provinces are always in attendance, regardless of whether they should sit quietly or debate. In other words, phenomenal states allow for the channels of communication across systems to always be open.

Chronic engagement allows one to reconceptualize why one continues to endure aversive states when performing adaptive actions (e.g., running across the hot desert sand to reach water). Although the benefits far outweigh the costs of such actions, and although the skeletomotor system allows one to carry out the costly action, one nonetheless experiences an aversive state. This reflects that the incentive system that modulates pain, for example, is encapsulated from the systems (e.g., the water-intake and instrumental systems) that influence the observed action. Because the outputs of all the systems are always phenomenally represented (whether one deems them helpful or not), one experiences the pain state. The bizarre situation that Chomsky (1988) identified is now reencountered, in which one can be inclined, but not compelled, to act a certain way.

Returning to the scorching plate example, one can understand the inclination to continue carrying the dish as arising in part from the food-intake system and the inclination to drop the dish as arising from the tissue-damage system. Without phenomenal states, these incentive outputs would be encapsulated from each other and from those of the instrumental system, which is necessary for navigating through space. Again, because of chronic engagement, the outputs from these systems would be phenomenally represented even if there were no conflict (e.g., if the dish were tepid or if one did not care about dropping it).[16]

It should be reiterated that SIT claims that phenomenal states are necessary for allowing cross-talk among the response systems, not that they are necessary for issuing skeletomotor actions. Unconscious responses to incentive stimuli occur quite often, as when one automatically orients the body toward a loud sound or withdraws one's hand from a hot stove. Such actions can be executed fast and automatically. Because of chronic engagement, one is often aware of these actions only after they have occurred, but awareness is unnecessary for their execution. If, however, there is conflict among systems (e.g., one actually decides, for some reason, to continue touching the hot stove), then phenomenal states are required to yield directed action. In other words, withdrawing

[15] There is an important conceptual distinction between *inhibition* (e.g., of an efferent signal in the central nervous system) and *counteraction* (Lorenz, 1963), as when micturition and the patellar reflex are counteracted by contracting the external urethral sphincter and leg muscles, respectively.

[16] The criteria predicting what enters awareness may, at first glance, seem exhaustively capacious, but this is mainly because the predicted contents happen to consist of all that we can ever know of directly. In other words, with respect to nervous processes, the conditions predicted to involve phenomenal states are actually less all encompassing than what subjective experience leads one to believe. As mentioned above, it is easy to disregard the number, nature, and complexity of impenetrable mechanisms, an oversight that has shrouded the unique role of phenomenal states. SIT proposes that the circumstances requiring phenomenality are actually a small subset of all bodily processes, narrowly consisting of those processes that involve interactions among relatively few, well-defined systems.

one's hand from physical harm does not require consciousness, but withstanding harm does. In activities not involving response systems (e.g., peristalsis and kidney–heart interactions), not even the direct effects of automatic action may enter awareness.

Chronic engagement allows one to reconceptualize the "food under heavy ice" example. In this scenario, the food-intake system induces the phenomenality of hunger and incentivizes the stimulus beneath the ice (Bindra, 1974; Dickinson & Balleine, 1995), the instrumental system has the cool goal of lifting the ice (Bindra, 1974), and the tissue-damage system induces negative affect once the heavy ice is lifted. Again, in this framework, adaptive action requires, not a homunculus, but a mode of interaction and checks and balances across systems (Kimberg et al., 1997; Minsky, 1985). For example, if the food-intake system were absent, one would be indifferent toward the food under the ice; if the instrumental system were absent, one would not know how to remove the ice; and if the tissue-damage system were absent, one would be indifferent to the damage caused by lifting the ice. Hence, without phenomenal states, the three systems would be unable to interact and yield adaptive action.

### *Ontogenesis and Meta-Cognition*

It is reasonable to assume that, early in development, skeletomotor behavior openly reflects the (unchecked and unsuppressed) tendencies of the response systems. There is no question that an infant or toddler would immediately drop a plate that was a bit too hot. But as development unfolds, behavior begins to reflect the collective development of the quasi-independent learning histories of the response systems. In parallel, the incentive systems learn through various forms of incentive learning (e.g., Pavlovian and observational incentive learning; Olsson & Phelps, 2004), and the instrumental system acquires an elaborate repertoire of actions through various forms of instrumental learning (e.g., ideomotor, operant, vicarious, latent).

Apart from their basic, integrative function during the execution of a single act, phenomenal states also serve a higher meta-cognitive function, in terms of how action selection is influenced in the long term (J. R. Gray, 2004; Schwarz & Clore, 1996). These states can indicate the relative costs of action plans in terms of the amount of strife they engender: Of two action plans leading to the same goal, one would rationally select the plan associated with less internal strife (e.g., pressing a button instead of enduring tissue damage for the same end). Interestingly, the basic parameters underlying the "subjective cost" of many actions (e.g., enduring tissue damage) seem to have been set in phylogeny. For example, regardless of developmental and environmental contingencies, negative affect tends to be associated with tissue damage, muscle fatigue, and extreme temperatures. It could be argued that, in the course of development, harmony is sought among the response systems and an elaborate form of homeostasis is achieved (see Dempsey, 1951, for a forward-looking treatment of the cognitive aspects of homeostasis). However, this higher, meta-cognitive function of phenomenal states is secondary to the integrative function they play during the execution of a single action. I now review the tenets of SIT, as follows:

1. In accord with the integration consensus, phenomenal states allow information from diverse sources to interact in order to produce adaptive action.

2. In contrast to the integration consensus, SIT proposes that there are relatively few kinds of information that require conscious interaction, because many kinds of information can interact unconsciously.

3. Phenomenal states are required for the outputs of different supramodular response systems to interact. These systems are agentic, multimodal, information-processing structures defined, not in terms of their sensory inputs, but in terms of their concerns.

4. Interactive processes occurring among modules within response systems can be unconscious, but interactive processes across systems require conscious processing.

5. As predicted by PRISM, in contrast to unconscious systems and processes, the response tendencies of response systems may conflict with skeletal muscle plans.

6. As described by the notion of chronic engagement, the outputs of the response systems incessantly modulate the phenomenal field, regardless of whether there is conflict.

7. Without phenomenal states, the outputs of the different systems would be encapsulated and incapable of collectively influencing action.

### *Reconceptualizing Previous Findings*

According to SIT, when phenomenal states are unavailable (e.g., because of some nervous system anomaly), action will occur but will be uninfluenced by the combined agendas of the response systems. With this in mind, it is reasonable to hypothesize that phenomena such as blindsight (Weiskrantz, 1992, 1997), in which patients report that they see nothing although they exhibit visually guided behavior (Cowey & Stoerig, 1995), reflect a lack of interaction among different response systems. (For a recent critical reevaluation of the claim that blindsight patients lack visual phenomenology, see O'Brien & Opie, 1999.) From this standpoint, although there is skeletomotor negotiation with the environment, no behaviors can reflect an incentive–instrumental integration.[17] Thus, these patients can navigate through a space, but their behavior is not purposeful: When hungry, they cannot seek food; when thirsty, they cannot seek water. Seeking food, for example, requires the combined outputs of the instrumental system (to navigate through space and grab the food object) and of the food-intake system (to desire and ingest food).

Accordingly, in other disorders in which action seems to be decoupled from phenomenal states, behavior is often perceived as impulsive, situationally inappropriate, and uncooperative (Chan & Ross, 1997). For example, in alien hand syndrome (Bryon &

[17] SIT claims that phenomenal states are necessary, although certainly not sufficient, for the production of actions reflecting interactions among different response systems. It should be clarified that if such actions (e.g., incentive–instrumental behaviors) are lacking (as in many neuropsychological disorders), it does not necessarily follow that, according to SIT, phenomenal processing should also be impaired, just as blindness does not imply that a person's eyes are impaired, although eyes are necessary but not sufficient for normal vision.

Jedynak, 1972), anarchic hand syndrome (Marchetti & Della Sala, 1998), and utilization behavior syndrome (Lhermitte, 1983), brain damage causes hands and arms to function autonomously, carrying out relatively complex goal-directed behavior (e.g., the manipulation of tools; Yamadori, 1997) that are maladaptive and, in some cases, at odds with a patient's reported intentions. Patients describe such actions as foreign and dissociated from their conscious will (Marchetti & Della Sala, 1998). (Less complex actions, such as automatic ocular pursuit and some reflexes, can also occur in some forms of coma and persistent vegetative states; Pilon & Sullivan, 1996.) Although such phenomena have been explained as resulting from impaired supervisory processes (e.g., Shallice, Burgess, Shon, & Boxter, 1989), SIT proposes that they are symptoms of a more basic condition—the lack of adequate cross-talk among response systems.

In contrast, normal reflexive behaviors reflect a harmless and adaptive lack of cross-talk among systems. The pupillary reflex, for example, can be carried out without phenomenal states because whether it should occur is independent of the agendas of the response systems. In evolutionary history, it seems humans did not control their pupillary reflex to, say, gain food or water, avoid pain, or perform any other action that involves coordination with skeletal muscle plans. The same holds for many of the operations in language production, speech perception, and other operations that do not require interactions with the systems. Perhaps most informative is the fact that, as mentioned above, in processes such as digestion, respiration, and excretion, one can be conscious only of the stages of the processes that require coordination with skeletal muscle plans.

Accordingly, not requiring such cross-talk, unconscious perceptual processes (e.g., as in the attentional blink; Raymond, Shapiro, & Arnell, 1992) involve smaller networks of brain areas than phenomenal processes, which have been proposed to yield flexible processes that take various kinds of information into account (Sergent & Dehaene, 2004). Likewise, in terms of action, automatic behaviors (e.g., reflexive pharyngeal swallowing) are believed to involve substantially fewer brain regions than their intentional counterparts (e.g., volitional swallowing; Kern et al., 2001; Ortinski & Meador, 2004). Moreover, beyond cognitive operations, one will never be conscious of activities such as those regulating blood pressure and glucose levels in the blood because they do not require communication across systems to yield adaptive action.

It is intriguing to ponder whether, given the appropriate conditions and despite the PRISM principle, impenetrable processes can become penetrable. For example, is it the case that, if system cross-talk is required for the adaptive execution of a reflex, one would become aware of the mediation of the reflex? More specifically, if one needed to suppress the pupillary reflex to obtain food (e.g., in some contrived laboratory situation), would one then be aware of what it is like to constrict or dilate the pupil? I favor a negative answer, for it seems that the task domain of phenomenal states has been set in phylogeny, where there seemed to have been no selection pressure for cross-talk between, say, the pupillary reflex and the need for food.

In SIT, phenomenal states are reconceptualized as organismic responses. The instrumental and incentive systems are "response" systems in the sense that the modulation of a phenomenal aspect (e.g., that of color, hunger, thirst, or pain) is construed as the response of an information-processing system. This view is consistent with Lashley's (1956) provocative statement that "no activity of mind is ever conscious" (p. 4), meaning that one is aware only of the products of cognitive processes, not of the processes themselves (Nisbett & Wilson, 1977). However, SIT adds to this perspective, for one is aware of at least some aspects of one kind of process—the computational process underlying the interaction of system outputs. The output from this consciously mediated computation is reflected perhaps only in behavior. From this perspective, humans experience two qualitatively different kinds of responses when confronted with input data: a phenomenal response and a behavioral one. This two-component model of action paints an obviously more complicated picture of nervous function than Descartes' reflex arc.

### *Specific Predictions*

At this stage of theoretical development, it is advantageous to base initial predictions not on the complex, extensive, and innumerable capacities of phenomenal processes but on the essential role these processes are proposed to serve in intersystem coordination. Thus, in addition to the hypotheses based on PRISM (presented above), which predict the conditions under which processes will involve phenomenal states, predictions that are more tractable stem from the limitations of unconscious processes as set forth by SIT.

As in blindsight and normal functioning, unconscious processes can yield elaborate skeletomotor actions. One thinks of how baseball players can hit a fastball faster than they can consciously perceive, or how skilled musicians can execute each note of an arpeggio faster than they can consciously plan (Lashley, 1951). Considering incentive action, there is automatic pain withdrawal, breathing, blinking, licking, chewing, drinking, swallowing, and other incentive-related behaviors that can occur reflexively once the incentive stimuli activate the appropriate receptors (Bindra, 1974). Phenomenal processing is unnecessary for the expression of such elaborate skeletomotor responses. Without these states, the instrumental and incentive systems can function independently.

However, SIT proposes that response-system cross-talk requires phenomenal processing. Figuratively speaking, the instrumental system is blind to what the food-intake system sees, and vice versa. Rational behavior is based in part on adequate cross-talk between the systems. Without phenomenal states, acts would be fractured and aimless (Sherrington, 1906). Therefore, SIT predicts that without conscious mediation, it is impossible to perform an instrumental act for an incentive. Thus, although some forms of Pavlovian and evaluative conditioning may occur unconsciously (Duckworth et al., 2002; Field, 2000; Olson & Fazio, 2001), traditional examples of operant conditioning such as pressing a lever to obtain food or avoid shock cannot occur unconsciously.

More specifically, SIT predicts that, without phenomenal mediation, one would be incapable of blinking, moving a limb, or grasping and tugging a joystick for an incentive. Faced with a joystick, one may well perform this skeletomotor act unconsciously and accidentally, for it is a behavior that joysticks afford. Likewise, as mentioned above, forms of eating can occur unconsciously. However, SIT predicts that without conscious mediation, an instrumental act cannot occur more or less often than what would be expected under normal circumstances (i.e., when there is no obvious incentive to influence action). Naturally, systematic effects reflecting a lack of incentive–instrumental coordination are also predicted to occur when there is malfunctioning of just the instrumental system or of any single incentive system (e.g., as in disorders of awareness involving pain, hunger, or thirst).

In addition, SIT proposes that phenomenal states are necessary, not to express or suppress actions but, more precisely, to suppress the action tendencies of response systems. Hence, it predicts that although one can unconsciously respond to harmful stimuli, one cannot unconsciously withstand any degree of tissue damage for some end. As mentioned above, the tissue-damage system is inflexibly concerned with avoiding physical harm. Thus, SIT predicts that, without phenomenal states, this system would cause one to avoid damage even when sustaining such damage is adaptive. By extension, regardless of the nature of the operant contingencies involved (e.g., reward or punishment), SIT predicts that, without phenomenal mediation, it is impossible to suppress or attenuate the response tendencies (e.g., blinking, reactions to muscle fatigue, and pain withdrawal) of any response system. (This prediction is consistent with the fact that one is incapable of voluntarily asphyxiating oneself, for one can hold one's breath only while conscious; Tortora, 1994.)

In addition, because enduring muscle fatigue requires interactions with the tissue-damage system, SIT predicts that although one can unconsciously exhibit a painless, previously learned instrumental act, one is incapable of unconsciously learning or exhibiting an instrumental act that induces muscle fatigue. Hence, one can appreciate that, without phenomenal states, activities such as arduous skill learning and exercise would be impossible, for there would be no forum in which the inclinations of the tissue-damage system could be counteracted.[18] These limitations are predicted to arise whenever phenomenal states are decoupled from action, either because of an anomaly (e.g., as in blindsight and alien hand syndrome) or because of subliminal processing.

Regarding subliminal processing, it has been demonstrated that when people are covertly primed with the stereotype of elderly persons, for example, they walk slower (Bargh, Chen, & Burrows, 1996, Experiment 2); when they are primed with the concept "rudeness," they are more likely to interrupt (Bargh et al., 1996, Experiment 1); and when they are primed with the concept "hostility," they become more aggressive (Carver, Ganellen, Froming, & Chambers, 1983). However, SIT predicts that although subliminal processes can influence the functioning of response systems (Bargh, 1990; Morsella et al., 2004; Morsella & Miozzo, 2002), they cannot prime one system to counter the tendencies of another system. Therefore, SIT predicts that subliminal processing cannot suppress or attenuate the response tendencies of any system.

In operational terms, covert presentation (e.g., following the procedures of Bargh & Chartrand, 2000) of stimuli such as words or images cannot counteract or attenuate inhaling, blinking, pruritus-induced scratching, pain withdrawal, or any of the other tendencies presented in Appendix B. More specifically SIT predicts that subliminal primes activating concepts such as "resist" or "endure" are incapable of inducing people to tolerate uncomfortable stimuli (e.g., cold water or loud noises) to an extent greater than what would be expected under normal circumstances. More generally, this hypothesis is consistent with research demonstrating that automatic tendencies can be curbed, but only with conscious mediation (Baumeister et al., 1994; Dunton & Fazio, 1997), and that they can be influenced to express certain action plans (e.g., eating popcorn) only when those plans are already motivated (e.g., when one is hungry; Strahan, Spencer, & Zanna, 2002).

Regarding the food-intake and water-intake systems, SIT proposes that under conditions of deprivation, phenomenal processing is required to resist consuming food or water once the appropriate stimuli are placed in the mouth. For example, the food-intake system will be inflexibly concerned with consuming a piece of food regardless of the aversive consequences (e.g., punishment) of performing the act. It is only because of intersystem communication, provided by phenomenal states, that the food-intake system cannot always express such an influence on behavior. More generally, SIT proposes that subliminal processing is incapable of curbing or attenuating any consummatory tendencies. Thus, for example, subliminal influences are predicted to be ineffective (and perhaps even counterproductive; Baumeister et al., 1994; Wegner, 2002) in activities such as fast-related dieting.

Given the complexity of the unconscious processes found in motor programs (Frith et al., 2000; Grossberg, 1999; Rosenbaum, 2002) and in higher mental functions (Bargh & Ferguson, 2000; Nisbett & Wilson, 1977), these predictions are far from obvious, far from infallible, and highly falsifiable. If it is demonstrated that any form of intersystem cross-talk can occur unconsciously (e.g., in disorders of awareness or via subliminal priming) or that the suppression of any one of the more than 20 response tendencies featured in Appendix B can occur unconsciously, then the model is falsified. Only empirical developments can address the issue.[19] For now, SIT sets response-system cross-talk as the boundary condition for unconscious processing.

## Discussion

SIT addresses what has been called a "deep and seemingly impenetrable question" (Banks, 1995, p. 271): What are phenomenal states for? Following Tolman (1948), Lashley (1951), and Chomsky (1959), the cognitive revolution of the 1950s reintroduced the idea of mind into experimental psychology. Much of the research since the 1950s has focused on the nature of mental processes and mental representation (see review in Markman & Dietrich, 2000). Yet, as Shallice (1972) concluded, the modern cognitive conceptualization of how the nervous system works leaves no functional role for what we identify as phenomenal states: "The problem of consciousness occupies an analogous position for cognitive psychology as the problem of language behavior does for behaviorism, namely, an unsolved anomaly within the domain of the approach" (Shallice, 1972, p. 383).

[18] Predictions relating to the incentive systems may lead one to the more parsimonious hypothesis that conscious processing is necessary, not for integrating response systems, but simply for inhibiting action. Unfortunately, this alternative hypothesis is readily falsified after considering the plethora of unconscious inhibition in nervous function and action planning (Li, Lindenberger, Rünger, & Frensch, 2000).

[19] The identification of the NCC will permit further tests of SIT in normals; for example, SIT predicts that actions reflecting any form of intersystem cross-talk are incapable of occurring during the transient and noninvasive deactivation of NCC brain regions (e.g., by transcranial magnetic stimulation).

For decades, behaviorism and the epiphenomenal stance have stifled research and theorizing on this topic (Koestler, 1967). As is often the case, the problem has reflected not a lack of data, but the lack of a conceptual framework with which to interpret the data (Grossberg, 1987). With the knowledge gained thus far and with the tools at hand, the time has come to stop treating these states as scientific nonissues (as in Huxley, 1874; Kinsbourne, 1996, 2000; Pinker, 1997).

Despite the prevalence of the epiphenomenal stance, theorists from diverse research lines have begun to reach a consensus that phenomenal states yield adaptive behavior by allowing different kinds of information to interact. SIT is consistent with the general premises of the various approaches composing this consensus. As posited by Baars's (1988) "global workspace" framework and conscious access hypothesis (Baars, 2002), SIT proposes that these states integrate nervous processes that are otherwise separate and independent. SIT is also in accord with proposals that phenomenal states deal with situations that require a multidetermined, flexible, nonstereotypical response (Crick & Koch, 2000; Searle, 2005; Sergent & Dehaene, 2004) and with Dennett's (2001) important claim that such a workspace (or forum) should be construed, not as the cause of consciousness, but as being consciousness. Unlike SIT, however, the approaches forming this consensus have been unable to specify which kinds of information and systems require conscious cross-talk, which kinds do not, and what is special about the task demands of conscious interactions.

Regarding the stages-of-processing associated with these states, SIT is consistent with Jackendoff's (1990) view that consciousness reflects some form of intermediate, action planning stage in between sensory and motor processing. It is generally accepted that the operations and representations underlying motor planning and control are unconscious (Berthoz, 2002; Grossberg, 1999; Rosenbaum, 2002). SIT adds to this perspective. Conscious conflicts suggest that not only is one unaware of such premotor processes, but one is also unaware of the computational products of these conflicts, that is, of the putative representations determining the general course of observed action. As mentioned above, one is conscious of a conflict but not of the representations reflecting the resolution of the conflict, if such representations exist. In stages-of-processing terms, this observation suggests that phenomenal states may be associated with stages that, although clearly subsequent to those of sensory processing (Hochberg, 1998; Logothetis & Schall, 1989; Marcel, 1993), may precede even those of action selection.

Considering the murkiness of the concept of consciousness (Block, 1995), I have attempted to keep SIT clear, parsimonious, minimalistic, and falsifiable, at the cost of depriving the construct of its sublime intricacy. For example, following Johnson and Reeder (1997), I attempted to focus on the basic, primary function of phenomenal states and avoid the complexity of higher level, potentially meta-cognitive phenomena, such as the role of phenomenal states in the sense of the self (Kihlstrom, 1987) and in the experience of agency and "will" (Wegner, 2002).

I hope that, together with the growing interest in consciousness, SIT will provide a fecund and progressive framework. One strength of SIT is that it is based on robust phenomena. There is little disagreement concerning the existence and general nature of the pupillary reflex, the ventriloquism effect, binocular rivalry, and the McGurk effect, nor is there debate regarding whether one is consciously aware of pain or hunger. In addition, SIT distinguishes conscious from unconscious concerns on the basis of concrete, unambiguous physiological characteristics such as basic, uncontroversial bodily needs (B. A. Campbell & Misanin, 1969; Dempsey, 1951) and the nature of the effectors involved (skeletal muscle). In addition, SIT is falsifiable: For example, if it is found that unconscious processes can suppress any response tendency, or resolve conflicts between any two response systems, then SIT is falsified, and more will have been learned about these elusive states.

To review, on the basis of the integration consensus, large-scale systems frameworks (Bindra, 1974; Metcalfe & Mischel, 1999), and uncontroversial, convergent findings from diverse areas of research, SIT proposes that phenomenal states, because of their physical properties, solve a computational problem for the cognitive apparatus by allowing supramodular response systems to interact.[20] Without these states, behavior would be fractured and purposeless (for a related notion, see Dickinson, 2001). The phenomenal field thus constitutes a forum in which communication across systems occurs.

The evolutionary trend toward increased compartmentalization of function in the nervous system[21] led to various forms of integrative solutions, including unconscious reflexes (N. A. Campbell, 1993; Sherrington, 1906) and neural convergence (Damasio, 1989). A fundamental assumption underlying SIT is that although intersystem integration could conceivably occur without something like phenomenal states (as in an automaton or in an elegant "blackboard" neural network with all of its modules nicely interconnected), such a solution was not selected in our evolutionary history. Instead, and for reasons that only the happenstance and tinkering process of evolution could explain (Gould, 1977; Simpson, 1949), I propose that these physical adaptations were selected to solve this large-scale, cross-talk problem.

Theoretically, nervous mechanisms could have evolved to solve the need for this particular kind of interaction otherwise. Apart from automata, which act like humans but have no phenomenal experience,[22] one could imagine a conscious nervous system that operates as humans do but does not suffer any internal strife. In such a system, knowledge guiding skeletomotor action would be isomorphic to, and never at odds with, the nature of the phenomenal state—running across the hot desert sand in order to reach

[20] One may argue that SIT does not really address the function of phenomenal states but that it simply specifies the conditions under which these states occur (a critical source of new information in its own right), but such an account would not lead to the kinds of descriptions and predictions furnished by SIT (e.g., those regarding the specific functional deficits that would arise without these states).

[21] In phylogeny, the introduction of new structures (e.g., organs and tissues) involves complex, often competitive interactions with extant ones; this "struggle of parts" problem (cf. Mayr, 2001) may have been a formidable challenge during the evolution of something as complex as the human nervous system.

[22] The nature of a human-like automaton is eloquently illustrated by Moody (1994): "Suppose there is a world much like our own, except for one detail: the people of this world are insentient. They engage in complex behaviors very similar to ours, including speech, but these behaviors are not accompanied by conscious experience of any sort. I shall refer to these beings as zombies" (p. 196).

water would actually feel good, because performing the action is deemed adaptive. Why our nervous system does not operate with such harmony is perhaps a question that only evolutionary biology can answer. Certainly one can imagine such integration occurring without anything like phenomenal states, but from the present standpoint, this reflects more one's powers of imagination than what has occurred in the course of evolutionary history. Using Marr's (1982) terminology, phenomenal states are the "implementational" level solution to the "computational" problem of integrating the tendencies of different response systems. Furthermore, it is assumed that conscious and unconscious integrations are carried out by physical processes that are qualitatively different in nature.

That two qualitatively different systems can interact to solve a computational goal is best illustrated by the following slot-machine example (Morsella, 2003). Because of their deterministic design, traditional computers are incapable of generating a truly random event and, hence, cannot produce random numbers. Computerized slot machines, for example, are not truly random in nature. However other physical systems, such as those at the quantal level, are truly random in nature (Greene, 1999). With this in mind, engineers can have slot-machines procure random numbers by having their computers refer to a random event (e.g., a decaying radioactive diode). In this case, a computational goal is achieved by having two different kinds of systems interacting with each other, with each system benefiting from the physical properties of the other. Likewise, the assumption here is that the computational goals that humans confront require at least two kinds of physical processing—one phenomenal and one unconscious.

From this point of view, attempting to explain how humans function without invoking phenomenal states is analogous to attempting to explain how radios work without implicating the electromagnetic spectrum. The mind–body problem or, better stated, the mind–matter problem may stem not so much from our ignorance regarding the relation between phenomenal states and the brain but from our ignorance of the physical world itself (Chomsky, 1988), a world that is far from devoid of mysteries. The mind–body problem has always been presented as "How could something like phenomenal states emerge from something like physical events?", as if the latter comprises only simplistic phenomena such as levers, vacuum pumps, and pulleys. Never is it considered that explaining something as commonplace as electrical charge requires adding eight imperceptible dimensions to the three that humans can perceive (Greene, 1999). In conclusion, there is room in the physical world, and enough complexity in the brain, for something as labyrinthine as phenomenal states.

Concerning the hard problem, SIT throws light on the kinds of mechanisms that may underlie the generation of these states, favoring those mechanisms that can bind, cross-talk, or converge information from different, high-level processes. Consistent with this, many hypotheses concerning the neural mechanisms underlying these states have pointed to processes that serve a signaling or communicative role, as in models implicating the synchronized firing of cell assemblies (for a reevaluation and rejection of this hypothesis, see Crick & Koch, 2003), the resonances among neural networks (Grossberg, 1999), and the simultaneous activation of cortical modules (Kinsbourne, 2000; Tononi & Edelman, 1988). As stimulating as these hypotheses are, explaining the mechanisms by which phenomenal states physically carry out intersystem cross-talk is a variant of the hard problem and is thus beyond the scope of the present theory.

With respect to biological systems, "how" and "why" questions are fundamentally different from "what for" questions (Lorenz, 1963; Simpson, 1949). SIT addresses only the latter, and, even so, it raises many thorny questions. Some of them can be answered only experimentally and others by research in evolutionary biology. For example, how many incentive response systems are there and what are their neural substrates? What are the principles governing the outcomes of conscious interactions (see Baumeister et al., 1994; Strack & Deutsch, 2004)?[23] Why does the instrumental system seem to have privileged access to skeletal muscle? Key questions also remain concerning the nature of the outputs of the systems: What are the properties of that which is represented phenomenally and how do these properties vary across systems?[24] (For thoughtful treatments of the properties of phenomenal percepts, and of percepts in general, see J. A. Gray, 1995; Hochberg, 1998; Lambie & Marcel, 2002; O'Regan & Noë, 2001.) Nevertheless, these challenges are far less daunting than the vast explanatory gap encountered with the prevalent epiphenomenal stance.

With this new conceptualization of the human nervous system, one could appreciate that there are three qualitatively different events in Sherrington's (1906) input–output arc: the unconscious detection and processing of stimuli, the phenomenal response (for intersystem interaction), and the observed skeletomotor response. Contrary to the tenets of traditional input–output accounts such as behaviorism, actions seem to be produced, not in a simple "if *x*, then *y*" manner, but by a dynamic system in which multiple inclinations strive to influence action collectively. At a minimum, SIT builds on the integration consensus and large-scale systems frameworks (Bindra, 1974; J. R. Gray, 2004; Metcalfe & Mischel, 1999; Öhman & Mineka, 2001) and allows one to appreciate that (a) not all kinds of integration involve phenomenal processing, (b) conscious and unconscious processes may be distinguished by the nature of the effectors involved, and (c) the difference between conscious and unconscious processes cannot simply reflect how complex, controlled, planned, integrative, or top-down the processes are. Beyond such ramifications, the framework may have implications for treatments of disorders of awareness.

[23] It is humbling to consider the perplexing complexity of the interactions involving only basic incentives (B. A. Campbell & Misanin, 1969).

[24] Delineating the nature of phenomenal representations is beyond the scope of SIT, though the term *response tendency* implies the nontraditional view that the properties of these representations are intimately related to action production rather than to perceptual processes. Sperry (1952) espoused this notion, claiming that the phenomenal percept (e.g., the shape of a banana) is more isomorphic with its related action plans than with its sensory input (the proximal stimulus on the retina). Historically, theorists have divorced input from output processes (Eimer, Hommel, & Prinz, 1995) and have envisaged phenomenal representations as consisting primarily of sensory-like traces (cf. Barsalou, 1999) rather than action-like ones. Sperry's (1952) view is consistent with the theory of event coding (TEC; Hommel et al., 2001), which attempts to bridge the historical gap between perception and action. TEC proposes that perceptual and action codes activate each other by sharing the same representational format.

## References


Angell, J. R. (1907). The province of functional psychology. *Psychological Review, 14,* 61–91.

Baars, B. J. (1988). *A cognitive theory of consciousness.* Cambridge, England: Cambridge University Press.

Baars, B. J. (1997). Some essential differences between consciousness and attention, perception, and working memory. *Consciousness and Cognition, 6,* 363–371.

Baars, B. J. (1998). The function of consciousness: Reply. *Trends in Neurosciences, 21,* 201.

Baars, B. J. (2002). The conscious access hypothesis: Origins and recent evidence. *Trends in Cognitive Sciences, 6,* 47–52.

Baker, T. B., Piper, M. E., McCarthy, D. E., Majeskie, M. R., & Fiore, M. C. (2004). Addiction motivation reformulated: An affective processing model of negative reinforcement. *Psychological Review, 111,* 33–51.

Banks, W. P. (1995). Evidence for consciousness. *Consciousness and Cognition, 4,* 270–272.

Bargh, J. A. (1990). Auto-motives: Preconscious determinants of social interaction. In E. T. Higgins & R. M. Sorrentino (Eds.), *Handbook of motivation and cognition* (Vol. 2, pp. 93–130). New York: Guilford Press.

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253–285). Cambridge, England: Cambridge University Press.

Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action. *Journal of Personality and Social Psychology, 71,* 230–244.

Bargh, J. A., & Ferguson, M. J. (2000). Beyond behaviorism: On the automaticity of higher mental processes. *Psychological Bulletin, 126,* 925–945.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22,* 577–609.

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation.* San Diego, CA: Academic Press.

Bernstein, L. J., & Robertson, L. C. (1998). Illusory conjunctions of color and motion with shape following bilateral parietal lesions. *Psychological Science, 9,* 167–175.

Berridge, K. C., & Robinson, T. E. (1995). The mind of an addicted brain: Neural sensitization of wanting versus liking. *Current Directions in Psychological Science, 4,* 71–76.

Berthoz, A. (2002). *The brain's sense of movement.* Cambridge, MA: Harvard University Press.

Bindra, D. (1974). A motivational view of learning, performance, and behavior modification. *Psychological Review, 81,* 199–213.

Bindra, D. (1976). *A theory of intelligent behavior.* New York: Wiley-Interscience.

Bindra, D. (1978). How adaptive behavior is produced: A perceptual-motivational alternative to response-reinforcement. *Behavioral and Brain Sciences, 1,* 41–91.

Block, N. (1995). On a confusion about a function of consciousness. *Behavioral and Brain Sciences, 18,* 227–287.

Bruner, J. S., & Goodman, C. C. (1947). Value and need as organizing factors in perception. *Journal of Abnormal and Social Psychology, 42,* 33–44.

Bryon, S., & Jedynak, C. P. (1972). Troubles du transfert interhemispherique: A propos de trois observations de tumeurs du corps calleux. Le signe de la main etrangère [Disorders of interhemispheric transfer (callosal disconnection): Three cases of tumor of the corpus callosum. The strange hand sign]. *Revue Neurologique, 126,* 257–266.

Campbell, B. A., & Misanin, J. R. (1969). Basic drives. *Annual Review of Psychology,* 20, 57–84.

Campbell, N. A. (1993). *Biology* (3rd ed.). Redwood City, CA: Benjamin/Cummings.

Carlson, N. R. (1994). *Physiology of behavior.* Needham Heights, MA: Allyn & Bacon.

Carver, C. S. (2004). Negative affects deriving from the behavioral approach system. *Emotion, 4,* 3–22.

Carver, C. S., Ganellen, R. J., Froming, W. J., & Chambers, W. (1983). Modeling: An analysis in terms of category accessibility. *Journal of Experimental Social Psychology, 19,* 403–421.

Chalmers, D. (1995). Facing up to the problem of consciousness. *Journal of Consciousness Studies, 2,* 200–219.

Chalmers, D. (1996). *The conscious mind: In search of a fundamental theory.* New York: Oxford University Press.

Chan, J.-L., & Ross, E. D. (1997). Alien hand syndrome: Influence of neglect on the clinical presentation of frontal and callosal variants. *Cortex, 33,* 287–299.

Chartrand, T. L., & Bargh, J. A. (2002). Nonconscious motivations: Their activation, operation, and consequences. In A. Tesser, D. Stapel, & J. Wood (Eds.), *Self and motivation: Emerging psychological perspectives* (pp. 13–41). Washington, DC: American Psychological Association.

Chomsky, N. (1959). A review of B. F. Skinner's "Verbal Behavior." *Language, 35,* 26–58.

Chomsky, N. (1988). *Language and problems of knowledge: The Managua lectures.* Cambridge, MA: MIT Press.

Clark, A. (2002). Is seeing all it seems? Action, reason and the grand illusion. *Journal of Consciousness Studies, 9,* 181–202.

Cowey, A., & Stoerig, P. (1995). Blindsight in monkeys. *Nature, 373,* 247–249.

Crick, F., & Koch, C. (1995). Are we aware of neural activity in primary visual cortex? *Nature, 375,* 121–123.

Crick, F., & Koch, C. (2000). The unconscious homunculus. In T. Metzinger (Ed.), *Neural correlates of consciousness* (pp. 103–110). Cambridge, MA: The MIT Press.

Crick, F., & Koch, C. (2003). A framework for consciousness. *Nature Neuroscience, 6,* 1–8.

Curtis, C. E., & D'Esposito, M. (2003). Success and failure suppressing reflexive behavior. *Journal of Cognitive Neuroscience, 15,* 409–418.

Damasio, A. R. (1989). Time-locked multiregional retroactivation: A systems-level proposal for the neural substrates of recall and recognition. *Cognition, 33,* 25–62.

Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness.* New York: Harcourt Brace.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition, 79,* 1–37.

Dempsey, E. W. (1951). Homeostasis. In S. S. Stevens (Ed.), *Handbook of experimental psychology* (pp. 209–235). New York: Wiley.

Dennett, D. C. (1991). *Consciousness explained.* London: Little, Brown.

Dennett, D. C. (2001). Are we explaining consciousness yet? *Cognition, 79,* 221–237.

de Waal, F. B. M. (2002). Evolutionary psychology: The wheat and the chaff. *Current Directions in Psychological Science, 11,* 187–191.

Dickinson, A. (2001). The 28th Bartlett Memorial Lecture. Causal learning: An associative analysis. *Quarterly Journal of Experimental Psychology: Comparative and Physiological Psychology, 54B,* 3–25.

Dickinson, A., & Balleine, B. W. (1995). Motivational control of instrumental action. *Current Directions in Psychological Science, 4,* 162–167.

Dickinson, A., & Balleine, B. W. (2000). Causal cognition and goal-directed action. In C. Heyes & L. Huber (Eds.), *The evolution of cognition: Vienna series in theoretical biology* (pp. 185–204). Cambridge, MA: MIT Press.

Dijksterhuis, A., & Bargh, J. A. (2001). The perception-behavior expressway: Automatic effects of social perception on social behavior. In M. P.

Zanna (Ed.), *Advances in experimental social psychology* (Vol. 33, pp. 1–40). San Diego, CA: Academic Press.

Donald, M. (2001). *A mind so rare: The evolution of human consciousness.* New York: Norton.

Dorris, M. C., Pare, M., & Munoz, D. P. (1997). Neuronal activity in monkey superior colliculus in preparation and execution of anti-saccades and pro-saccades. *Journal of Neuroscience, 17,* 8566–8579.

Dretske, F. (1997). What good is consciousness? *Canadian Journal of Philosophy, 27,* 1–15.

Drzezga, A., Darsow, U., Treede, R.-D., Siebner, H., Firsch, M., Munz, F., Weilke, F., Ring, J., Schwaiger, M., & Bartenstein, P. (2001). Central activation by histamine-induced itch: Analogies to pain processing: A correlational analysis of O-15 $H_2O$ positron emission tomography studies. *Pain, 92,* 295–305.

Duckworth, K. L., Bargh, J. A., Garcia, M., & Chaiken, S. (2002). The automatic evaluation of novel stimuli. *Psychological Science, 13,* 513–519.

Dulany, D. E. (1991). Conscious representation and thought systems. In R. S. Wyer & T. K. Srull (Eds.), *The content, structure, and operation of thought systems: Advances in social cognition* (Vol. 4, pp. 97–120). Hillsdale, NJ: Erlbaum.

Dunton, B., & Fazio, R. H. (1997). An individual difference measure of motivation to control prejudiced reactions. *Personality and Social Psychology Bulletin, 23,* 316–326.

Eccles, J. C., & Popper, K. R. (1977). *The self and its brain.* New York: Routledge.

Eimer, M., Hommel, B., & Prinz, W. (1995). S-R compatibility and response selection. *Acta Psychologica, 90,* 301–323.

Ernst, M. O., & Bülthoff, H. H. (2004). Merging the senses into a robust percept. *Trends in Cognitive Sciences, 8,* 162–169.

Field, A. P. (2000). I like it, but I'm not sure why: Can evaluative conditioning occur without conscious awareness? *Consciousness and Cognition, 9,* 13–36.

Fodor, J. A. (1983). *Modularity of mind: An essay on faculty psychology.* Cambridge, MA: MIT Press.

Franz, V. H., Gegenfurtner, K. R., Bülthoff, H. H., & Fahle, M. (2000). Grasping visual illusions: No evidence for a dissociation between perception and action. *Psychological Science, 11,* 20–25.

Freeman, W. J. (1991). The physiology of perception. *Scientific American, 264,* 78–85.

Frijda, N. H. (1986). *The emotions.* Cambridge, England: Cambridge University Press.

Frith, C. D., Blakemore, S. J., & Wolpert, D. M. (2000). Abnormalities in the awareness and control of action. *Philosophical Transactions of the Royal Society of London, 355,* 1771–1788.

Gallistel, C. R. (1980). *The organization of action: A new synthesis.* Hillsdale, NJ: Erlbaum.

Gallistel, C. R., & Gibbon, J. (2001). Computational versus associative models of simple conditioning. *Current Directions in Psychological Science, 10,* 146–150.

Giles, H., Coupland, J., & Coupland, N. (1991). *Contexts of accommodation: Developments in applied sociolinguistics.* New York: Cambridge University Press.

Gould, S. J. (1977). *Ever since Darwin: Reflections in natural history.* New York: Norton.

Gray, J. A. (1995). The contents of consciousness: A neuropsychological conjecture. *Behavioral and Brain Sciences, 18,* 659–676.

Gray, J. R. (2004). Integration of emotion and cognitive control. *Current Directions in Psychological Science, 13,* 46–48.

Green, K. P., & Miller, J. L. (1985). On the role of visual rate information in phonetic perception. *Perception & Psychophysics, 38,* 269–276.

Greene, B. R. (1999). *The elegant universe: Superstrings, hidden dimensions, and the quest for the ultimate theory.* New York: Norton.

Greenwald, A. G., & Pratkanis, A. R. (1984). The self. In R. S. Wyer & T. K. Srull (Eds.), *Handbook of social cognition* (pp. 129–178). Hillsdale, NJ: Erlbaum.

Grossberg, S. (1987). *The adaptive brain, Vol. 1.* Amsterdam: North-Holland.

Grossberg, S. (1999). The link between brain learning, attention, and consciousness. *Consciousness and Cognition, 8,* 1–44.

Harless, E. (1861). Der Apparat des Willens [The apparatus of will]. *Zeitshrift für Philosophie und philosophische Kritik, 38,* 499–507.

Hesslow, G. (2002). Conscious thought as simulation of behavior and perception. *Trends in Cognitive Sciences, 6,* 242–247.

Hobson, J. A. (2000). *Consciousness.* New York: Scientific American Library.

Hochberg, J. (1998). Gestalt theory and its legacy: Organization in eye and brain, in attention and mental representation. In J. Hochberg (Ed.), *Perception and cognition at century's end: Handbook of perception and cognition* (2nd ed., pp. 253–306). San Diego, CA: Academic Press.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding: A framework for perception and action planning. *Behavioral and Brain Sciences, 24,* 849–937.

Hopfield, J. J. (1984). Neurons with graded response have collective computational properties like those of two-state neurons. *Proceedings of the National Academy of Sciences, USA, 81,* 3088–3092.

Huxley, T. H. (1874). *Animal automatism, and other essays.* New York: J. Fitzgerald.

Jack, A. I., & Shallice, T. (2001). Introspective physicalism as an approach to the science of consciousness. *Cognition, 79,* 161–196.

Jackendoff, R. S. (1990). *Consciousness and the computational mind.* Cambridge, MA: MIT Press.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jacoby, L. L., Yonelinas, A. P., & Jennings, J. M. (1997). The relations between conscious and unconscious (automatic) influences: Toward showing independence. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to consciousness* (pp. 13–47). Mahwah, NJ: Erlbaum.

James, W. (1890). *The principles of psychology.* New York: Dover.

Jeannerod, M. (2003). Simulation of action as a unifying concept for motor cognition. In S. H. Johnson-Frey (Ed.), *Taking action: Cognitive neuroscience perspectives on intentional acts* (pp. 139–163). Cambridge, MA: MIT Press.

Johnson, M. K., & Reeder, J. A. (1997). Consciousness as meta-processing. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to consciousness* (pp. 261–293). Mahwah, NJ: Erlbaum.

Jousmaki, V., & Hari, R. (1998). Parchment-skin illusion: Sound-biased touch. *Current Biology, 8,* R190–R191.

Kern, M. K., Jaradeh, S., Arndorfer, R. C., & Shaker, R. (2001). Cerebral cortical representation of reflexive and volitional swallowing in humans. *American Journal of Physiology: Gastrointestinal and Liver Physiology, 280,* G354–G360.

Kihlstrom, J. F. (1987, September 18). The cognitive unconscious. *Science, 237,* 1445–1452.

Killeen, P. R. (2001). The four causes of behavior. *Current Directions in Psychological Science, 10,* 136–140.

Kimberg, D. Y., D'Esposito, M., & Farah, M. J. (1997). Cognitive functions in the prefrontal cortex—Working memory and executive control. *Current Directions in Psychological Science, 6,* 185–192.

Kinder, A., & Shanks, D. R. (2003). Neuropsychological dissociations between priming and recognition: A single-system connectionist account. *Psychological Review, 110,* 728–744.

Kinsbourne, M. (1996). What qualifies a representation for a role in consciousness? In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to consciousness* (pp. 335–355). Hillsdale, NJ: Erlbaum.

Kinsbourne, M. (2000). How is consciousness expressed in the cerebral activation manifold? *Brain and Mind, 2,* 265–274.

Klein, D. B. (1984). *The concept of consciousness: A survey.* Lincoln: University of Nebraska Press.

Knuf, L., Aschersleben, G., & Prinz, W. (2001). An analysis of ideomotor action. *Journal of Experimental Psychology: General, 130,* 779–798.

Koch, C. (2004). *The quest for consciousness: A neurobiological approach.* Englewood, CO: Roberts.

Koestler, A. (1967). *The ghost in the machine.* New York: Macmillan.

Kouider, S., & Dupoux, E. (2004). Partial awareness creates the “illusion” of subliminal semantic priming. *Psychological Science, 15,* 75–81.

LaBar, K. S., Gitelman, D. R., Parrish, T. B., Kim, Y.-H., Nobre, A. C., & Mesulam, M.-M. (2001). Hunger selectively modulates corticolimbic activation to food stimuli in humans. *Behavioral Neuroscience, 115,* 493–500.

Lambie, J. A., & Marcel, A. J. (2002). Consciousness and the varieties of emotion experience: A theoretical framework. *Psychological Review, 109,* 219–259.

Lashley, K. S. (1951). The problem of serial order in behavior. In L. A. Jeffress (Ed.), *Cerebral mechanisms in behavior. The Hixon symposium* (pp. 112–146). New York: Wiley.

Lashley, K. S. (1956). Cerebral organization and behavior. *Proceedings of the Association for Research in Nervous and Mental Diseases, 36,* 1–18.

Lavond, D. G., Kim, J. J., & Thompson, R. F. (1993). Mammalian brain substrates of aversive classical conditioning. *Annual Review of Psychology, 44,* 317–342.

LeDoux, J. E. (1996). *The emotional brain: The mysterious underpinnings of emotional life.* New York: Simon & Schuster.

LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience, 23,* 155–184.

Lhermitte, F. (1983). “Utilization behavior” and its relation to lesions of the frontal lobes. *Brain,* 237–255.

Li, K. Z., Lindenberger, U., Rünger, D., & Frensch, P. A. (2000). The role of inhibition in the regulation of sequential action. *Psychological Science, 11,* 343–347.

Llinas, R. R. (2002). *I of the vortex: From neurons to self.* Cambridge, MA: MIT Press.

Llinas, R. R., & Ribary, U. (2001). Consciousness and the brain: The thalamocortical dialogue in health and disease. *Annals of the New York Academy of Sciences, 929,* 166–175.

Logan, G. D., Taylor, S. E., & Etherton, J. L. (1999). Attention and automaticity: Toward a theoretical integration. *Psychological Research, 62,* 165–181.

Logothetis, N. K. (1998). Object vision and visual awareness. *Current Opinions in Neurobiology, 8,* 536–544.

Logothetis, N. K., & Schall, J. D. (1989, August 18). Neuronal correlates of subjective visual perception. *Science, 245,* 761–762.

Lorenz, K. (1963). *On aggression.* New York: Harcourt, Brace, & World.

Lotze, R. H. (1852). *Medizinische Psychologie oder Physiologie der Seele* [Medical psychology or the physiology of the soul]. Leipzig, Germany: Weidmann'sche Buchhandlung.

Luria, A. R. (1932). *The nature of human conflicts, or emotion, conflict and will: An objective study of the disorganisation and control of human behavior.* New York: Liveright.

Macphail, E. M. (1998). *The evolution of consciousness.* New York: Oxford University Press.

Mandler, G. (1997). Consciousness redux. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to consciousness* (pp. 479–498). Mahwah, NJ: Erlbaum.

Mandler, G. (1998). Consciousness and mind as philosophical problems and psychological issues. In J. Hochberg (Ed.), *Perception and cognition at century's end: Handbook of perception and cognition* (2nd ed., pp. 45–65). San Diego, CA: Academic Press.

Marcel, A. J. (1993). Slippage in the unity of consciousness. In G. R. Bock & J. Marsh (Eds.), *Experimental and theoretical studies of consciousness* (pp. 168–180; Ciba Foundation Symposium 174). Chichester, England: Wiley.

Marchetti, C., & Della Sala, S. (1998). Disentangling the alien and anarchic hand. *Cognitive Neuropsychiatry, 3,* 191–207.

Markman, A. B., & Dietrich, E. (2000). Extending the classical view of representation. *Trends in Cognitive Sciences, 4,* 470–475.

Marr, D. (1982). *Vision.* New York: Freeman.

Mayr, E. (2001). *What evolution is.* London: Weidenfeld & Nicolson.

McDonald, J. J., & Ward, L. M. (2000). Involuntary listening aids seeing: Evidence from human electrophysiology. *Psychological Science, 11,* 167–171.

McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature, 264,* 746–748.

McMurray, G. A. (1950). Experimental study of a case of insensitivity to pain. *Archives of Neurology and Psychiatry, 64,* 650–667.

Melzack, R., & Casey, K. L. (1968). Sensory, motivational, and central control determinants of pain: A new conceptual model. In D. R. Kenshalo (Ed.), *The skin senses* (pp. 423–443). Springfield, IL: Charles C Thomas.

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review, 106,* 3–19.

Miller, N. E. (1959). Liberalization of basic S-R concepts: Extensions to conflict behavior, motivation, and social learning. In S. Koch (Ed.), *Psychology: A study of science* (Vol. 2, pp. 196–292). New York: McGraw-Hill.

Milner, A. D., & Goodale, M. (1995). *The visual brain in action.* New York: Oxford University Press.

Minsky, M. (1985). *The society of mind.* New York: Simon & Schuster.

Mischel, W., Shoda, Y., & Rodriguez, M. I. (1989, May 26). Delay of gratification in children. *Science, 244,* 933–938.

Moody, T. C. (1994). Conversations with zombies. *Journal of Consciousness Studies, 1,* 196–200.

Morsella, E. (2003). The function of phenomenal states: Is there progress for the “softer problem” of consciousness? *Psychological Reports, 93,* 435–440.

Morsella, E., Levine, L. R., & Bargh, J. A. (2004). *Nonconscious activation of action plans: A cascade model of automatic social behavior.* Unpublished manuscript, Yale University.

Morsella, E., & Miozzo, M. (2002). Evidence for a cascade model of lexical access in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 555–563.

Nagasako, E. M., Oaklander, A. L., & Dworkin, R. H. (2003). Congenital insensitivity to pain: An update. *Pain, 101,* 213–219.

Nagel, T. (1974). What is it like to be a bat? *Philosophical Review, 83,* 435–450.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84,* 231–259.

Norman, D. A., & Shallice, T. (1980). *Attention to action: Willed and automatic control of behavior* (Technical Report No. 8006). San Diego: University of California, San Diego, Center for Human Information Processing.

O'Brien, G., & Opie, J. (1999). A connectionist theory of phenomenal experience. *Behavioral and Brain Sciences, 22,* 127–196.

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review, 108,* 483–522.

Olson, M. A., & Fazio, R. H. (2001). Implicit attitude formation through classical conditioning. *Psychological Science, 12,* 413–417.

Olsson, A., & Phelps, E. A. (2004). Learned fear of “unseen” faces after Pavlovian, observational, and instructed fear. *Psychological Science, 15,* 822–828.

O'Regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences, 24,* 939–1031.

Ortinski, P., & Meador, K. J. (2004). Neuronal mechanisms of conscious awareness. *Neurological Review, 61,* 1017–1020.

Pavlov, I. P. (1927). *Conditioned reflexes.* Oxford, England: Oxford University Press.

Pilon, M., & Sullivan, S. J. (1996). Motor profile of patients in minimally responsive and persistent vegetative states. *Brain Injury, 10,* 421–437.

Pinker, S. (1997). *How the mind works.* New York: Norton.

Pins, D., & Ffytche, D. (2003). The neural correlates of conscious vision. *Cerebral Cortex, 13,* 461–474.

Prinz, W. (2003). How do we know about our own actions? In S. Maasen, W. Prinz, & G. Roth (Eds.), *Voluntary action: Brains, minds, and sociality* (pp. 21–33). London: Oxford University Press.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance, 18,* 849–860.

Reisberg, D. (2001). *Cognition: Exploring the science of the mind* (2nd ed.). New York: Norton.

Remez, R. E. (1994). A guide to research on the perception of speech. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 145–172). New York: Academic Press.

Remez, R. E., Rubin, P. E., Berns, S. M., Pardo, J. S., & Lang, J. M. (1994). On the perceptual organization of speech. *Psychological Review, 101,* 129–156.

Rolls, E. T., Judge, S. J., & Sanghera, M. (1977). Activity of neurones in the inferotemporal cortex of the alert monkey. *Brain Research, 130,* 229–238.

Rolls, E. T., & Treves, A. (1998). *Neural networks and brain function.* New York: Oxford University Press.

Rosenbaum, D. A. (2002). Motor control. In H. Pashler (Series Ed.) & S. Yantis (Vol. Ed.), *Stevens' handbook of experimental psychology: Vol. 1. Sensation and perception* (3rd ed., pp. 315–339). New York: Wiley.

Roser, M., & Gazzaniga, M. S. (2004). Automatic brains: Interpretive minds. *Current Directions in Psychological Science, 13,* 56–59.

Schwarz, N., & Clore, G. L. (1996). Feelings and phenomenal experiences. In E. T. Higgins & A. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 433–465). New York: Guilford Press.

Searle, J. R. (2000). Consciousness. *Annual Review of Neurosciences, 23,* 557–578.

Searle, J. R. (2005, January 13). Consciousness: What we still don't know [Review of the book *The quest for consciousness: A neurobiological approach*]. *New York Review of Books, 52*(1).

Sechenov, I. M. (1863). *Reflexes of the brain.* Cambridge, MA: MIT Press.

Sergent, C., & Dehaene, S. (2004). Is consciousness a gradual phenomenon? Evidence for an all-or-none bifurcation during the attentional blink. *Psychological Science, 15,* 720–728.

Shallice, T. (1972). Dual functions of consciousness. *Psychological Review, 79,* 383–393.

Shallice, T., Burgess, P. W., Shon, F., & Boxter, D. M. (1989). The origins of utilization behavior. *Brain, 112,* 1587–1598.

Shepherd, G. M. (1994). *Neurobiology* (3rd ed.). New York: Oxford University Press.

Sherrington, C. S. (1906). *The integrative action of the nervous system.* New Haven, CT: Yale University Press.

Simpson, G. G. (1949). *The meaning of evolution.* New Haven, CT: Yale University Press.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Smythies, J. (1997). The functional neuroanatomy of awareness: With a focus on the role of various anatomical systems in the control of intermodal attention. *Consciousness and Cognition, 6,* 455–481.

Sober, S. J., & Sabes, P. N. (2003). Multisensory integration during motor planning. *Journal of Neuroscience, 23,* 6982–6992.

Sperry, R. W. (1952). Neurology and the mind-brain problem. *American Scientist, 40,* 291–312.

Stein, B. E., Wallace, M. T., & Meredith, M. A. (1995). Neural mechanisms mediating attention and orientation to multisensory cues. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 683–702). Cambridge, MA: MIT Press.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Bulletin, 8,* 220–247.

Strahan, E., Spencer, S. J., & Zanna, M. P. (2002). Subliminal priming and persuasion: Striking while the iron is hot. *Journal of Experimental Social Psychology, 38,* 556–568.

Stuss, D. T., & Anderson, V. (2004). The frontal lobes and theory of mind: Developmental concepts from adult focal lesion research. *Brain & Cognition, 55,* 69–83.

Thorndike, E. L. (1911). *Animal intelligence.* New York: Macmillan

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review, 55,* 189–208.

Tononi, G., & Edelman, G. M. (1988, December 4). Consciousness and complexity. *Science, 282,* 1846–1851.

Tortora, G. J. (1994). *Introduction to the human body: The essentials of anatomy and physiology* (3rd ed.). New York: HarperCollins.

Tranel, D., & Damasio, A. R. (1985, June 21). Knowledge without awareness: An autonomic index of facial recognition by prosopagnosics. *Science, 228,* 1453–1454.

Tranel, D., & Damasio, A. R. (1993). The covert learning of affective valence does not require structures in hippocampal system or amygdala. *Journal of Cognitive Neuroscience, 5,* 79–88.

Tucker, M., & Ellis, R. (2001). The potentiation of grasp types during visual object categorization. *Visual Cognition, 8,* 769–800.

Tucker, M., & Ellis, R. (2004). Action priming by briefly presented objects. *Acta Psychologica, 116,* 185–203.

Tulving, E. (2002). Chronesthesia: Conscious awareness of subjective time. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 311–325). London: Oxford University Press.

Ungerleider, L. G., & Mishkin, M. (1982). Two cortical visual systems. In D. J. Ingle, M. A. Goodale, & R. J. W. Mansfield (Eds.), *Analysis of visual behavior* (pp. 549–586). Cambridge, MA: MIT Press

Varela, F., Lachaux, J. P., Rodriguez, E., & Martinerie, J. (2001). The brainweb: Phase synchronization and large-scale integration. *National Review of Neuroscience, 2,* 229–239.

Vroomen, J., & de Gelder, B. (2003). Visual motion influences the contingent auditory motion aftereffect. *Psychological Science, 14,* 357–361.

Watanabe, K., & Shimojo, S. (2001). When sound affects vision: Effects of auditory grouping on visual motion perception. *Psychological Science, 12,* 109–116.

Wegner, D. M. (2002). *The illusion of conscious will.* Cambridge, MA: MIT Press.

Wegner, D. M., & Bargh, J. A. (1998). Control and automaticity in social life. In D. T. Gilbert, S. T. Fiske, & G. Lindsey (Eds.), *The handbook of social psychology* (Vol. 1, 4th ed., pp. 446–496). Boston, MA: McGraw-Hill.

Weiskrantz, L. (1992). Unconscious vision: The strange phenomenon of blindsight. *The Sciences, 35,* 23–28.

Weiskrantz, L. (1997). *Consciousness lost and found: A neuropsychological exploration.* New York: Oxford University Press.

Wraga, M., Creem, S. H., & Proffitt, D. R. (2000). Perception-action dissociations of a walkable Müller-Lyer configuration. *Psychological Science, 11,* 239–243.

Wundt, W. (1900). *Die sprache* [Language]. Leipzig, Germany: Engelmann.

Yamadori, A. (1997). Body awareness and its disorders. In M. Ito, Y. Miyashita, & E. T. Rolls (Eds.), *Cognition, computation, and consciousness* (pp. 169–176). Washington, DC: American Psychological Association.

Zeki, S., & Bartels, A. (1999). Toward a theory of visual consciousness. *Consciousness and Cognition, 8,* 225–259.

## Appendix A

### Representative Phenomena Involving Unconscious Interactions

Pupillary reflex
McGurk effect (McGurk & MacDonald, 1976)
Binocular rivalry
Audiovestibular interactions (e.g., after spinning)
Gustatory-olfactory interactions in flavor perception
Visuotactile interactions (e.g., in perceiving objects; Ernst & Bülthoff, 2004)
Audiotactile interactions (e.g., the parchment-skin illusion; Jousmaki & Hari, 1998)
Ventriloquism and other audiovisual interactions (McDonald & Ward, 2000; Watanabe & Shimojo, 2001)
Visuopropioceptive interactions (e.g., during reaching; Sober & Sabes, 2003)
In visual perception, interactions among modular processing of color, motion, and shape (Bernstein & Robertson, 1998; Zeki & Bartels, 1999)
In depth perception, interactions among modular processing of diverse cues (e.g., motion parallax, texture gradients, sound source; Hochberg, 1998)
In hunger perception, interaction among processing of blood glucose levels, temperature, triglyceride content (B. A. Campbell & Misanin, 1969)
In pain perception, interaction between sensory (lateral pain system) and affective components (medial pain system; Melzack & Casey, 1968; Nagasako, Oaklander, & Dworkin, 2003)

## Appendix B

### Supramodular Response Systems

*Principal characteristics*: Multimodal, informationally encapsulated systems with inflexible concerns and individual learning histories and operating principles. Unlike unconscious systems and concerns (e.g., for circulation and the pupillary reflex), their goals may interfere with skeletal muscle plans. Each system can influence action unconsciously, but their outputs can interact only in the phenomenal field.

*Instrumental Response System:* A "cool" system; privileged access to skeletal muscle; capable of instrumental, vicarious, and latent learning; planned actions can be understood in terms of ideomotor principles; enacts instrumental goals, which are subjectively experienced as *instrumental wants.*

*Incentive Response Systems*: "Hot" systems; capable of incentive learning (e.g., fear and appetitive conditioning). Table B1 shows nine basic classes of incentive systems and some of their response tendencies.

Table B1

Classes of Incentive Systems

| Classes of response systems | Representative response tendencies |
|---|---|
| Air intake | Inhaling, gagging, yawning, and some forms of coughing |
| Tissue damage | Automatic forms of blinking, sneezing, coughing, postural shifting, pruritus-induced scratching, reactions to muscle fatigue, and pain withdrawal |
| Water intake and food intake | Licking, chewing, swallowing, and other behaviors (e.g., the rooting and sucking reflexes) that can occur automatically once stimuli activate the appropriate receptors |
| Elimination (three classes) | Micturating, defecating, and regurgitating |
| Temperature | Taxis away from uncomfortable temperatures. For temperatures not activating pain receptors (i.e., between 10° and 45° C), decreased skeletomotor activity for high temperatures and increased activity for low temperatures |
| Sleep onset | Closing eyes and loss of postural muscle tone |

Received September 25, 2003
Revision received March 23, 2005
Accepted March 28, 2005 ■