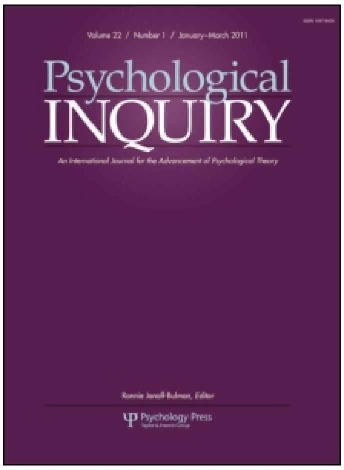

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What Is an Output?

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What Is an Output?

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A recurrent idea in the history of psychology is that one is conscious of outputs but not of the complex processes underlying the generation of outputs, which is evident in the out-of-the-blue, "eureka-like" experiences associated with intuition. We examine how this idea may suffer from a logical fallacy and may thus have inadvertently hindered progress on the study of the intimate liaisons among high-level central processes, intuition, and overt action. It is proposed that, for various reasons, the only undisputable output in the nervous system is overt action. Once this is accepted, the overlooked relationship between conscious central processes and overt action can be examined. A review of the evidence reveals that conscious processing is in the business of, not low-level perceptual processing, motor control, or action production per se, but of constraining a peculiar form of knowledge-based, integrated action-goal selection, which can lead to integrated actions such as holding one's breath. Unconscious processing can influence behavior indirectly, by producing these conscious constraining dimensions that modulate action-goal selection, or directly, through unintegrated actions such as reflexively inhaling or responding to a subliminal stimulus. From this standpoint, eureka-like intuitions reflect not an atypical brain process but the general nature by which unconscious machinations influence action either directly or indirectly, through the limited purview of consciousness.

> Inductive reasoning is the result of an unconscious and involuntary activity; and for this very reason it strikes our consciousness as a foreign and overpowering force of nature. — Helmholtz (1856/1925, p. 117)

Everyone has experienced a "eureka" moment. Hours after one has given up trying to solve a problem, its solution spontaneously enters one's mind, without any forewarning or effort on one's part. The solution may be how to rearrange the office furniture, the perfect title for a short story, or a forgotten name. For instance, if one experiences a tip-of-the-tongue (TOT) state when attempting to recall the name of the historic figure responsible for once exclaiming "Eureka!" one may find that "Archimedes" enters one's mind only hours later, long after one has given up trying to recall the name. As captured by Helmholtz's eloquent assertion, these thoughts appear to be the result (or *output*) of unconscious thinking, machinations occurring beneath the horizon of consciousness that are often perceived as separate from the self (Morsella, Berger, & Krieger, in press).

Helmholtz (1856/1925) referred to these unconscious machinations as *unconscious inferences*, a term that has historically been used to describe those sophisticated, "consciously-impenetrable," mechanisms constituting low-level perceptual analyses (e.g., depth perception, motion detection, color and auditory analyses; Zeki & Bartels, 1999). It is important to note that Helmholtz used the term in a more inclusive manner than it is used today. One of his cogent examples of unconscious inference was not about basic visual perception, but about the automaticity of word reading—one is faced with a word (*Tortoise*) and one cannot help but read it. In modern times, such observations are the object of study in investigations of *unconscious processing* (see review in Morsella & Bargh, in press) and *unconscious incubation* (see Dijksterhuis & Nordgren, 2006; Metcalfe & Weibe, 1987).

Faced with such observations, pioneers such as Lashley (1951) and Shepard (1984) have concluded that *one is conscious of the outputs of thinking but not of thinking itself*, a well-accepted idea that has recurred in the history of psychology (see similar views in Fodor, 1983; Gray, 2004; Jackendoff, 1990; Marcel, 1993; Nisbett & Wilson, 1977). (For short, we refer to this as the "conscious output" idea.) In this article, we examine how this beautiful idea may actually suffer from a logical fallacy and may thus have inadvertently hindered progress on the study of the liaisons among high-level central processes, intuition, and overt action. In the process, we contrast the nature of unconscious and conscious processing. We conclude by proposing that, as bizarre as they may seem, the "eureka-like" intuitions just mentioned reflect not an atypical brain process or cases of divine intervention but the general nature by which unconscious machinations influence action either directly or indirectly, through the limited contents and purview of consciousness.

The "Conscious Output" Fallacy

In his classic publication "The Concept of the Stimulus in Psychology," James J. Gibson (1960) compelled experimenters to take a moment to ponder the question, "What is a stimulus?"—a question that is substantially more complicated than it might appear at first glance. In the spirit of that article, we believe that the time has come to ponder a similar question about that which occurs at the other end of the input–output arc, one that is intimately related to the phenomenon of intuition: "What is an output?"

As previously mentioned, a recurrent idea in the history of psychology is that one is conscious of outputs but not of the many complicated machinations giving rise to them. Substantial research reveals that the little of that which we are conscious tends to reflect (a) what in everyday life is called "perception," or, more scientifically, "perceptual products," such as objects in the world (Fodor, 1983; Goodhew, Visser, Lipp, & Dux, in press; Gray, 1995, 2004; Neisser, 1967), (b) "evaluative products" (Damasio, 1996), such as positive or negative valences toward objects, and (c) "dispositional products," such as behavioral inclinations that are experienced subjectively (e.g., the urge to breathe while holding one's breath; Morsella, 2005; Pacherie, 2000). These basic conscious outputs include representations of objects in the world (e.g., a sofa, table, and fruit bowl), and one's valence and inclinations toward such objects (e.g., the urge to eat the liked fruits).

In a typical and simplified scenario, these three kinds of products account for much of what we are aware (Gray, 2004). On top of this, one can also be aware of high-level processes such as subvocalizations, a tune in one's head, intrusive cognitions, intuitions, nostalgia, and high-level cognitions such as the *feeling of knowing* during a TOT state or when solving a puzzle (Metcalfe & Weibe, 1987). In contrast, it seems that there is no conscious content about low-level perceptual processes or motor programs (Grossberg, 1999; Rosenbaum, 2002), including the programs associated with syntax/language (Levelt, 1989), aspects of emotional processing (e.g., amygdala; Anderson & Phelps, 2002; Öhman, Carlsson, Lundqvist, & Ingvar, 2007), and components of executive control (Crick & Koch, 2000; Suhler & Churchland, 2009). Again, this pattern of observations has been captured by the notion that one is conscious only of the high-level "outputs" of processes (e.g., "objecthood"; Goodhew et al., in press), not of the processes themselves, including their associated "lower level" outputs and motor programs (Fodor, 1983; Jackendoff, 1990; Lashley, 1951; Shepard, 1984).

Before continuing, it is important that we clarify that when speaking about conscious states, we are referring to the most basic form of consciousness, the kind falling under the rubrics of "subjective experience," "qualia," "sentience," "basic awareness," and "phenomenal state." This basic form of consciousness has been defined by Nagel (1974), who claimed that an organism has basic consciousness 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 the solution to a TOT state. Similarly, Block (1995) claimed, "the phenomenally conscious aspect of a state is what it is like to be in that state" (p. 227).

With all these considerations in mind, one can appreciate a potential fallacy of the "conscious output" idea. Of all the countless kinds of processes in the nervous system that could be construed as *outputs* (e.g., unconscious outputs from processes such as low-level perceptual analysis, cerebellar calculations, and syntax-related algorithms), conscious representations are distinguished as *the* outputs by virtue of only one quality: by their being conscious. From this standpoint, the only thing that differentiates conscious outputs from other outputs is that the former are conscious. Of course, this is a circular argument: When asked the question, "What distinguishes conscious outputs from the many other, unconscious outputs?" it is not informative for one to reply, "Conscious outputs are conscious." (One could always propose that, by definition, an output is a conscious representation, but then all that one has done is to redefine an output as any conscious event, with the former having no other defining properties than *being conscious* and the latter having no other defining properties than *being an output*.)

How then does one identify an output in the nervous system? Could one not argue that the outcome of any nervous process can constitute an output of sorts? What about the well-documented "activations" of word representations that, though never uttered or experienced consciously, can nonetheless influence processing (Levelt, 1989)? For example, there is substantial evidence that, when uttering the word *dog*, the word representation for the category-member CAT, too, is activated (Levelt, 1989; Morsella & Miozzo, 2002).

Can this activation of CAT be considered an output? Moreover, could one not argue that, at a lower level of nervous processing, the corrective firing of the Renshaw cell (a kind of neuron) is an output of sorts, or is such an event considered too "low level" to constitute an output?

Regarding levels of processing, there also are problems in identifying an output in terms of the "level" or "stage of processing" at which it occurs: What constitutes a high-level versus a low-level process/outcome is rather arbitrary, defined not in terms of something intrinsic about that process/outcome but only in relative terms, in reference to other stages or levels of processing. For example, regarding the term "high-level perceptual representation" (e.g., a representation reaching "objecthood"; Goodhew et al., in press), there is nothing intrinsic to the representation that renders it a distinguishable "output" apart from its place on a nebulous hierarchy beginning with low-level processes at the bottom and ending with high-level processes somewhere at the top. In conclusion, conscious representations/processes are simply conscious representations/processes; any "output-like" features they posses are shared by countless *unconscious* representations/processes.

Overt Action: The Undisputable Output

In line with the conclusions of many before us (Lorenz, 1965; Pavlov, 1927; Skinner, 1953; Sperry, 1952; Watson, 1912), an indisputable output of the nervous system is overt action (Bargh, 1997), a surprisingly underexplored object of research in psychology (Rosenbaum, 2005). (Historically, psychology has focused more on the problem of knowledge representation, as in perception and memory, than on that of *action production*; see Morsella, Bargh, & Gollwitzer, 2009; Rosenbaum, 2005.) With this more conservative view of what constitutes an output, one can construe the nervous system as having four distinct kinds of phenomena: *inputs* (external/bodily stimuli; see Gibson, 1960), *unconscious processes*, *conscious processes* (e.g., conscious representations), and veritable *outputs* (overt action). With this framework, one can begin to complement the historically prevalent research examining the liaison between inputs and conscious representations (as in the study of visual illusions and psychophysics more generally) by analyzing a less explored relationship—that between the output (overt action) and those central processes that are conscious.

To this end, Nobel Laureate Roger Sperry (1952) espoused that the conscious percept (e.g., the shape of a banana) is more isomorphic with its associated action plans (e.g., how one would draw the banana) than with its sensory input (the proximal stimulus on the retina) or other low-level perceptual processes. Sperry went on to propose that, by investigating the relationship between conscious representations and overt action, one can learn more about the nature of the inner workings of the mind/brain than by examining the relationship between inputs and central (conscious) processes. According to Sperry, examining the outputs of a machine (e.g., a smoothie from a blender) tells one more about the inner workings of the machine (e.g., the blending actions of the spinning blade) than does examining the machine inputs (e.g., fruit and milk). Unlike Sperry, theorists have historically envisaged conscious representations as consisting primarily of input-related traces (but see Barsalou, 1999) rather than action-related traces.

Sperry's example deals with a perceptual product, one of the several kinds of things one is conscious of, but the same applies to evaluations, inclinations, and intuitions, which can be argued to be more isomorphic with their related action plans than with the stimuli or low-level processes from which they emerge. (See Sheerer, 1984, for a review of the shortcomings of approaches in which the nature of percepts is based primarily on motor processing, as in "peripheralist," "motor," "efferent," and "reafferent" theories of thought; e.g., Festinger, Ono, Burnham, & Bamber, 1967; Hebb, 1968; Held & Rekosh, 1963; McGuigan, 1966; Münsterberg, 1891; Washburn, 1928; Watson, 1924. For contemporary treatments regarding how action influences the nature of conscious percepts, see Hommel, 2009, and O'Regan & Noë, 2001.)

Not only is overt action *the* undisputable output of concern in the study of nervous function, but it is also the output of concern in evolution. Unlike urges, inclinations, or beliefs, all of which are internal states, overt action is significant because it is the cognitive product that natural selection can operate on (Roe & Simpson, 1958): As Dawkins (1976) put it, "The main way in which brains actually contribute to the success of survival machines is by controlling and coordinating the contraction of muscles" (p. 49). Thus, throughout this article we adopt a Jamesian, functionalist approach in which *thinking is for doing* (James, 1890/1950) and in which, just the same, *intuiting is for doing.* From this standpoint, overt action is *the* output of central processing, which can include conscious and unconscious mechanisms. It is no accident that, when attempting to move forward the young science of psychology by identifying undisputable input–output contingencies, experimenters decided to focus on the relationship between stimuli and observed behavior rather than on stimuli and central processing (Pavlov, 1927; Skinner, 1953; Watson, 1912; see Bargh, 1997).

Only a small subset of the processes in the centralized system are associated with consciousness; the vast majority of the processes are unconscious (Bargh & Morsella, 2008; Goodale & Milner, 2004; Gray, 2004). So what is special about conscious processes?

The Atypicality of Consciousness and its Primary, Action-Related Role

Time past and time future allow but a little consciousness.

— T. S. Eliot, *The Four Quartets* (1952, p. 119)

Despite how much consciousness may mean to "us," with it forming the totality of our experience (Morsella, 2005), it is actually an atypical phenomenon and tool with respect to both the natural world and the majority of human nervous function. Figuratively speaking, it is as atypical regarding the nuts and bolts of intelligent behavior as are the computerized, GPS-based navigational systems in today's automobiles atypical with respect to how automobiles locomote (Bargh & Morsella, 2010). The vast majority of the processes in the brain are unconscious (Gray, 2004), and the nature of the few that are conscious are founded themselves on unconscious processing. Next we delineate how conscious processing is an atypical and well-circumscribed process that rests upon unconscious processing, just as out-of-the-blue intrusive cognitions and intuitions are based upon unconscious machinations. To understand the relationship between outputs (behaviors) and conscious processing, one has to first identify what distinguishes conscious from unconscious processing. (As we have learned, proposing that conscious representations are "outputs" does little to remedy the issue.)

There is a consensus that consciousness is associated with only a subset of nervous function. According to the *integration consensus* (Morsella, 2005), the instantiation of the conscious state permits representations/processes to be broadcasted and integrated with other kinds of information in a manner that cannot be achieved through unconscious processing alone (Baars, 1998; Clark, 2002; Damasio, 1989; Dehaene & Naccache, 2001; Del Cul, Baillet, & Dehaene, 2007; Doesburg, Green, McDonald, & Ward, 2009; Freeman, 1991; Llinás, Ribary, Contreras, & Pedroarena, 1998; Ortinski & Meador, 2004; Sergent & Dehaene, 2004; Tononi & Edelman, 1988; Ulhaas et al., 2009; Varela, Lachaux, Rodriguez, & Martinerie, 2001; Zeki & Bartels, 1999). Thus, conscious processing enables a kind of information integration that would not occur otherwise. One limitation of the integration consensus is that it does not specify which kinds of information require this form of conscious integration and which kinds do not. Supramodular Interaction Theory (SIT; Morsella, 2005) addresses this shortcoming.

From this standpoint, in the nervous system there are three distinct kinds of integration or "binding" (Morsella & Bargh, in press), only one of which requires the conscious state. Perceptual binding (or *afference binding*) is the binding of perceptual processes and representations. This occurs in intrasensory, feature binding (e.g., the binding of shape to color; Zeki & Bartels, 1999) and in intersensory conflicts, as in the McGurk effect. In the McGurk effect (McGurk & MacDonald, 1976), there are unconscious interactions between visual and auditory processes: An observer views a speaker mouthing "ga" while presented with the sound "ba." Surprisingly, the observer is unaware of any intersensory interaction, perceiving only "da." Similar consciously impenetrable interactions are exemplified in countless intersensory phenomena (see Appendix A in Morsella, 2005), including the popular ventriloquism effect, in which visual and auditory inputs regarding the source of a sound interact unconsciously (cf. Vroomen & de Gelder, 2003). At a minimum, these phenomena demonstrate that conscious states are unnecessary to integrate information from sources as diverse as the information from different modalities. Intersensory crosstalk can occur without consciousness.

Consideration of intersensory phenomena underscores the difficulty of identifying an output with respect to central processing: In the McGurk effect, is the output what the ear heard (/ba/) or what the eye saw (/ga/), or was it what the individual experienced (/da/)? In this case, as noted by Sperry, the conscious representation is what is most isomorphic to the real output—the subject reporting, "I heard /da/."

Another form of binding, linking perceptual processing to action/motor processing, is known as *efference binding* (Haggard, Aschersleben, Gehrke, & Prinz, 2002). This kind of stimulus-response ($S \rightarrow R$) binding is what allows one to learn to press a button when presented with a cue in a laboratory paradigm. Research has shown that responding on the basis of efference binding can occur unconsciously. For example, Taylor and McCloskey (1990, 1996) demonstrated that, in a choice response time task, participants could select the correct motor response (one of two button presses) when confronted with subliminal stimuli (see review in Hallett, 2007). Unconscious efference binding also occurs when one reflexively inhales while underwater or instinctively drops a hot dish of food.

The third kind of binding, *efference–efference binding*, occurs when two streams of efference binding (i.e., two independent $S \rightarrow R$ links) are trying to influence skeletomotor action simultaneously, as when one holds one's breath or suppresses a prepotent response (Figure 1). In SIT, it is the instantiation of conflicting efference–efference binding that requires consciousness. Consciousness is the "crosstalk" medium that allows such actional processes to influence

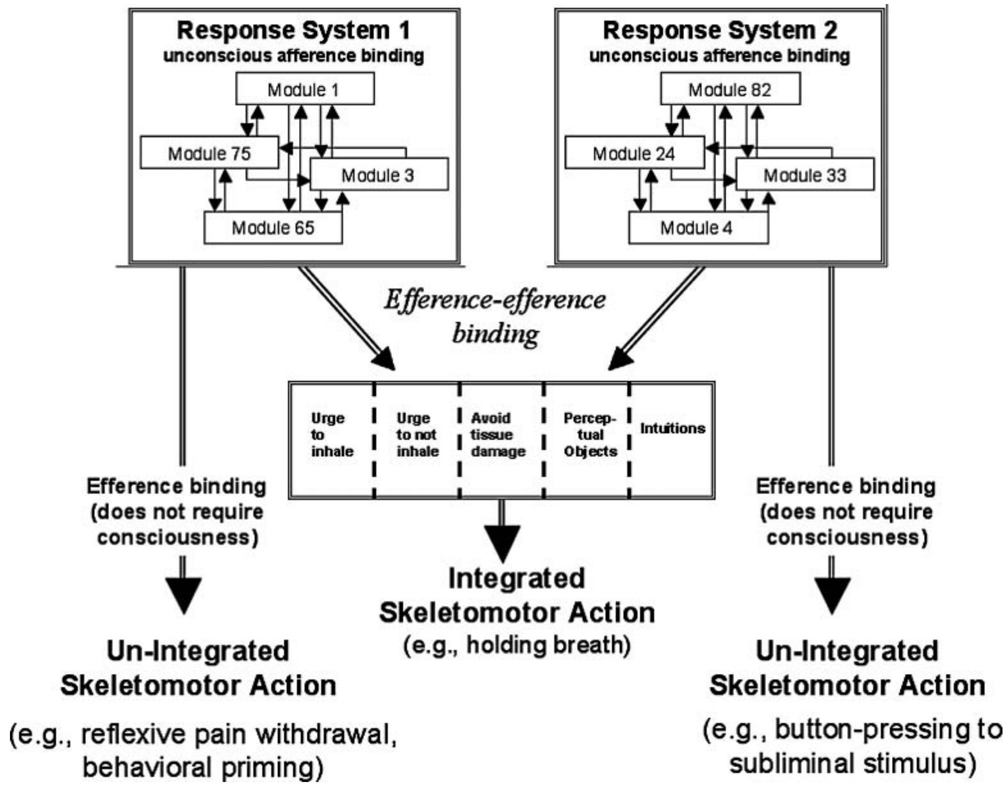

Figure 1. Fodorian modules operate within a few multimodal, supramodular response systems (only two presented), each defined by its concern. Afference binding within systems can be unconscious. *Note.* Although response systems can influence action directly (illustrated by the lateral arrows), only in virtue of conscious states can they can interact and influence action collectively. Five "constraining dimensions" occupy the conscious field (center).

action collectively. Absent consciousness, behavior can be influenced by only one of the efference streams, leading to *un-integrated* actions such as unconsciously inhaling while underwater, reflexively removing one's hand from a hot object, or responding to a subliminal stimulus (Morsella & Bargh, in press). According to SIT, one can breathe unconsciously, but consciousness is required for the *integrated action* of suppressing breathing. Similarly, one can unconsciously emit a pain-withdrawal response, but one cannot override such a response (a form of integrated action) without consciousness.

It is important to emphasize that consciousness is not necessary for action per se. In the rest of the animal kingdom, an actionless stupor is seldom observed in the repertoire of decapitated chickens, insects, frogs, or Sherrington's "spinal dogs." Even an isolated lizard tail can display behaviors (wiggling) that decoy predators and thus spare the rest of the lizard's body. Such reduced bodies certainly seem "alive," but few would argue that they retain whatever form of consciousness the intact animal had (if any). Moreover, in humans action still arises in the absence of consciousness but not in an "integrated" manner. When losing consciousness while holding one's breath underwater, it is not the case that the organism then experiences an actionless stupor; instead, it unconsciously performs the complicated action of inhaling. Apart from the kinds of unconscious efference binding observed in everyday life, unconscious efference binding can also be observed in neurological conditions in which consciousness is decoupled from action, as in *blindsight*, *blind-smell*, *anarchic hand syndrome*, *alien hand syndrome*, *utilization behavior syndrome*, *visual agnosia*, and *automatisms* observed during an epileptic seizure (see review of all forms in Morsella & Bargh, in press).

In conclusion, SIT builds on the integration consensus by proposing that consciousness is required to integrate information but only certain kinds of information. Specifically, it is required to integrate information from specialized, high-level (and often multimodal) systems that are unique in that they may conflict with skeletal muscle plans, as described by the principle of parallel responses into skeletal muscle (Morsella, 2005). (For the sake of brevity, we refer to skeletal muscle plans as skeletomotor plans.) These supramodular systems are defined in terms of their "concerns" (e.g., bodily needs) rather than their sensory afference. In contrast, defining systems in terms of their sensory afference (e.g., auditory vs. visual) has been the traditional approach to identifying mental faculties. Because they do not involve skeletal muscle plans, conflicts involving smooth muscle, (e.g., the pupillary reflex; Morsella, Gray, Krieger, & Bargh, 2009.) or intersensory processing (e.g., the McGurk conflict) can be resolved unconsciously.

Together, these observations reveal that consciousness is a well-circumscribed phenomenon. Consistent with Sperry's observations about the nature of conscious representation and voluntary action, SIT reveals that consciousness is intimately related to conflict at the response-selection stage of processing rather than at the perceptual stages of processing (see Baumeister & Masicampo, 2010, for a similar conclusion).

The Trinity: Isomorphisms Among Conscious Representations in Dreaming, Observing, and Doing

According to the integration consensus, consciousness crosstalks information and behavioral inclinations that were already generated and analyzed unconsciously (Baumeister & Masicampo, 2010; Jackendoff, 1990; Shepard, 1984). Thus, consciousness is not a doer but a talker, and it only crosstalks relatively few kinds of information, as specified previously. If the function of conscious states is to achieve integration among skeletomotor response systems by broadcasting information, then one would expect that the nature of representations involved in conscious processing have a high "broadcast ability," that is, that they can be understood by multiple action systems in the brain. This appears to be the case. It has been proposed a priori (on the basis of the requirements of "isotropic information" processing) that it is the perceptual-like (object) representation that is the kind of representation that would have the best broadcast ability in the brain (Fodor, 1983; Morsella, Lanska, Berger, & Gazzaley, 2009). Thus, perhaps it is no accident that it is the perceptual-like kind of representation (e.g., visual objects or linguistic objects such as phonemes; Fodor, 1983) that happens to be consciously available (Gray, 1995). (Convergent evidence for this stems from research elucidating why motor programs are necessarily unconscious; Gray, 1995; Grossberg, 1999; Prinz, 2003.) This conclusion begins to illuminate the nature of the representations that enter awareness in intuition.

When further examining the liaison between action and consciousness, one notices that there is an unmistakable isomorphism regarding that which one is conscious of when one is (a) dreaming, (b) observing the behaviors of others, and (c) observing one's own actions. In each case, it is the same, perceptual-like representation that constitutes that which is consciously available (Rizzolatti, Sinigaglia, & Anderson, 2008). Language provides an excellent example. Levelt (1989) argued that, of all the processes involved in language production, one is conscious only of a subset, whether when speaking aloud or only "in one's head" (i.e., subvocalizing). Consider that it is the phonological representation, and not, say, the motor-related, "articulatory code" (Ford, Gray, Faustman, Heinks, & Mathalon, 2005) that one is conscious of during spoken or subvocalized speech, or when perceiving the speech of others (Buchsbaum & D'Esposito, 2008; Fodor, 1983; Rizzolatti et al., 2008). From Sperry's action-based standpoint, it could be argued that the phonological representation (e.g., the sound of *dog*) is isomorphic to what would be experienced if one "produced" the representation, or if one heard someone else produce it, whether during waking life or in a dream. Again, it is the conscious representation (and not the activated representation for the category member CAT, or subphonemic contrasts; Fodor, 1983) that is most isomorphic with the products of overt action (the real output).

The idea of the contents of consciousness being perceptual-like is in accord with the view that conscious processes are intimately related to the construction of an internal simulation of both the external world and one's current place (and dispositions) within it (Hesslow, 2002; Merker, 2007; Morsella, Hoover, & Bargh, in press; Yates, 1985). As explained next, the evaluation that is required by the outcome of a simulation (the simulacrum) is based on knowledge that is already embodied in the agenda-based actional systems (Bargh & Morsella, 2008). This perceptual-based perspective is also in accord with the *ideomotor principle*, originating in the time of Lotze (1852), Harleß (1861), and Carpenter (1874). The principle states that action guidance and action knowledge are limited to perceptual-like representations (or, event codes; see Hommel, Müsseler, Aschersleben, & Prinz, 2001) of action outcomes (e.g., the "image" of one's finger flexing), with the motor programs/events actually responsible for enacting the actions being unconscious (Gray, 1995, 2004; Jeannerod, 2006; Rosenbaum, 2002; Rossetti, 2001). (See neuroimaging evidence for the ideomotor principle in Melcher, Weidema, Eenshuistra, Hommel, & Gruber 2008.) From this standpoint, conscious contents regarding ongoing action are primarily of the perceptual consequences of action (Jeannerod, 2006): "In perfectly simple voluntary acts there is nothing else in the mind but the kinesthetic idea . . . of what the act is to be" (James, 1890/1950, p. 771). (For a computational explanation of why motor programs should be unconscious, and explicit memories should be not formed for them, see Grossberg, 1999.) Thus, one is unconscious of the complicated programs that calculate which muscles should be activated at a given time but is often aware of their proprioceptive and perceptual consequences (e.g., perceiving a finger flex).

Consistent with contemporary ideomotor-like approaches (e.g., Greenwald, 1970; Hommel, 2009; Hommel & Elsner, 2009; Hommel et al., 2001), James (1890/1950) proposed that the conscious mind later uses these conscious perceptual-like representations to voluntarily guide the generation of motor efference, which itself is an unconscious process. In contrast, according to a minority (see list of four "dissenters" in James, 1890/1950, p. 772), one *is* aware of the efference to the muscles (Wundt's *feeling of innervation*; see James, 1890/1950, p. 771) that is responsible for action outcomes (see review in Sheerer, 1984). (Wundt later abandoned the feeling-of-innervation hypothesis; Klein, 1970.) In contrast, James (1890/1950) staunchly proclaimed, "There is no introspective evidence of the feeling of innervation" (p. 775).

In conclusion, perceptual-like representations seem to underlie the images in dreams, episodic memory, the observations of the actions of others and oneself, and in internal actions such as subvocalization. Although there has been substantial debate regarding the nature of conscious representations (e.g., whether they are "analogical" or "propositional"; Markman, 1999), few would argue about the isomorphism among the conscious representations experienced while acting (e.g., saying "hello"), dreaming (e.g., saying "hello" in the dream world), or observing the action of another (e.g., hearing "hello").

Can the kinds of representations/processes associated with conscious perceptual products, evaluative products, or dispositional products be explained as manifestations of a more basic process? The goal in science is to explain as many phenomena as possible with (a) as few principles as possible and with (b) the phenomena being manifestations of as few processes as possible (Einstein & Infeld, 1967). With this goal, theorists have attempted to explain that perceptual objects and inclinations—the seemingly dissimilar conscious phenomena that account for most of what one is conscious of—are actually manifestations of the same thing. At first glance, a perceptual object (e.g., a banana) and an inclination (e.g., the urge to breathe) seem to be very different kinds of things. As argued by Sperry, despite their phenomenological differences, both kinds of conscious content constrain voluntary action production. We address this functional account of these contents in the next section. Before doing so, we briefly review an attempt to unify these two kinds of content as manifestations of the same neural process.

It has been proposed that, in terms of stages of processing, that which characterizes conscious content is the notion of *perceptual afference* (information arising from the world that affects sensory-perceptual systems) or *perceptual reafference* (information arising from "corollary discharges" or "efference copies" of our own actions; cf. Christensen et al., 2007; Obhi, Planetta, & Scantlebury, 2009), both of which are cases of afferent processing. Sherrington (1906) aptly referred to these two similar kinds of information as *exafference* (when the source of information stems from the external world) and *reafference* (when the source is from our own actions). As just mentioned, it seems that we do not have direct, conscious access to motor programs or other kinds of "efference generators" (Grossberg, 1999; Rosenbaum, 2002), including those for language (Levelt, 1989), emotional systems (e.g., the amygdala; Anderson & Phelps, 2002; Öhman et al., 2007), or executive control (Crick & Koch, 2000; Suhler & Churchland, 2009). It is for this reason that, when speaking, one often does not know exactly which words one will say next until the words are uttered or subvocalized following word retrieval (Levelt, 1989; Slevc & Ferreira, 2006).

Now that we have examined the nature of conscious states and their contents from a neural perspective, we can ask the following question regarding function: If conscious representations/processes are not outputs, then what do they do?

Knowledge-Based Constraints on "Voluntary" Skeletomotor Action

We approach the topic of intuition and its "outputs" from an untraditional perspective—by working backwards from overt action to the underlying central processes (the evolved conscious and unconscious processes) that render action adaptive. We propose that, compared to other representations and nervous products, conscious representations are unique in their ability to constrain *skeletomotor action-goal selection* (action selection, for short), which has traditionally been considered a form of "voluntary" processing. (For a nonhomuncular definition of "voluntary" see Morsella, Lynn, & Riddle, in press; for present purposes, it is adequate to use the loaded and problematic term "voluntary".)

As evident in SIT, a challenge faced by the human nervous system is that each of its component systems may have different skeletomotor inclinations (i.e., "action goals") toward the same situation. An "action goal" is best defined by Skinner"s conception of an *operant* (Skinner, 1953). As in the case of *motor equivalence* (Lashley, 1942), several different behaviors can lead to the same action goal: A rat may depress a lever (the action goal) with its chin, teeth, front legs, or hind legs (i.e., via multiple means). In physiological terms, the skeletal muscle effector system is special in that, to a degree greater than that of any other effector system (e.g., cardiac or smooth muscle), distinct regions/systems of the brain, with different evolutionary histories, are trying to control it in different and often opposing ways. The skeletal muscle output system is akin to a single steering wheel that is controlled by multiple agentic systems, each with its peculiar operating principles and phylogenetic origins. Most effector systems do not suffer from this particular kind of multidetermined guidance. Although simple motor acts suffer from the "degrees of freedom" problem, because there are countless ways to instantiate a motor act such as grasping a handle (Rosenbaum, 2002), action selection suffers from this problem to an even greater degree. For action-goal selection, the challenge is met not by unconscious motor algorithms (as in the case of motor programming; Rosenbaum, 2002) but by the ability of conscious states to crosstalk information and constrain *what we do*, by having the inclinations of multiple systems constrain and curb skeletomotor output: One system "protests" one exploratory act (e.g., touching a flame), whereas another reinforces another act (e.g., eating something sweet).

Regarding action-goal selection, *first-level constraints* involve representing the world such that one can adaptively interact with its physical objects, as when one decides to pick fruit from a tree that is perceived to be closer than another tree. These are the allocentric perceptual representations, concerned with invariant aspects of the world, which are critical for action selection and proposed to be a property of the ventral pathway in the brain (Goodale & Milner, 2004). *Second-level constraints* involve incentive and affective systems that curb certain actions and reinforce others. When needs must be met, these constraints direct and sustain attention toward incentive stimuli. For example, though one's kitchen "looks" the same whether one is hungry or sated (Rolls, Judge, & Sanghera, 1977), more attention may be given to the cabinet with the cookie jar when one is hungry than sated (Yarbus, 1967). When needs must be met, reflexive attentional changes, such as the "visual grasp" reflex (Sumner & Husain, 2008), orient the organism toward the relevant incentive stimuli. The more attention that is given to an object, the more likely it is that a voluntary action, including the option of performing "no action" (which itself is a form of action: Morsella, Hoover, et al., in press; Skinner, 1953) will be emitted toward the object (Pacherie, 2008). Goodale and Milner (2004) proposed that, when a given allocentric perceptual representation becomes important with respect to a need, it is "flagged" by attention in the ventral stream. After action selection occurs, unconscious motor programs (e.g., in the dorsal stream) interact with the incentivized object. Speaking about the necessary division between representations for instrumental action and incentive representations, 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).

Along these lines, consider that, at one moment in time, a piece of food such as an apple can be treated as something to eat; at other times it may be used as a projectile to ward off an attacker. In both cases, first-level constraints allow one to negotiate the object properly. Second-level constraints represent how one should treat and attend to the object on the basis of current needs. One can imagine other, higher order constraints based on cultural learning (Baumeister & Masicampo, in press; MacDonald, 2008). According to SIT, first-level constraints and the different kinds of second-level constraints (e.g., for food, water, air) are the products of encapsulated response systems, each with its own agenda, operating principles, and phylogenetic origins.

In integrated action-goal selection, the "votes" that must be taken into account can be construed as tendencies based on inborn or learned knowledge, knowledge that has been proposed to reside in the neural networks of the ventral processing stream (Goodale & Milner, 2004). In the ventral stream, information about the world is represented in a unique manner (e.g., involving allocentric coordinates), one unlike that of the dorsal stream (e.g., representing the variant aspects of the world, using egocentric coordinates). Again, substantial evidence from diverse sources (Grossberg, 1999; Rosenbaum, 2002), including research on the properties of the dorsal visual processing stream (Goodale & Milner, 2004), reveals that online motor control and other forms of action can occur unconsciously (see Morsella & Bargh, in press). Because the physical spatial relationship between the objects of the world and one's body is in constant flux (e.g., a cup is sometimes at left or right), each time an action is performed, new motor programs must be generated online to deal with peculiarities of each setting, following which these "use only once" unconscious representations are scrapped (Grossberg, 1999; Rosenbaum, 2002). In contrast, representations of the ventral stream reflect unchanging aspects of the world that can be used not just to travel down memory lane but as knowledge to constrain future action (Schacter & Addis, 2007). This should not be taken to mean that the properties of conscious perceptual representations (e.g., the kind associated with the ventral processing stream; Goodale & Milner, 2004) are in a realm far removed from overt action. As Goodale and Milner (2004) concluded, "the primary role of perceptual representations is not in the *execution* of actions, but rather in helping the person or animal arrive at a decision to act in a particular way" (p. 48).

Dissociations between action and conscious perception are evident in the ways that neurologically intact participants respond to visual illusions (Wraga, Creem, & Proffitt, 2000). Illusions allow one to distinguish the difference between action selection and motor control. Consider the following scenario. In the Müller–Lyer illusion, vertical lines can be made to look longer by flanking them with open brackets

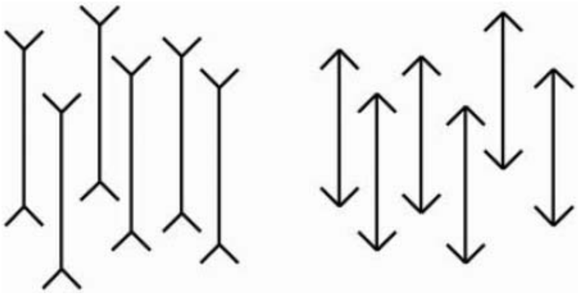

Figure 2. Which gang would you fight? *Note.* Although action selection is influenced by the illusion, in which the vertical lines on the right appear shorter than those on the left, motor interactions with the vertical lines would be unaffected by this "unconscious inference." The average viewer would choose to fight the shorter gang on the right, even though motor control during an altercation with each gang would be indistinguishable.

(Figure 2, left) and made to look shorter by flanking them with closed brackets (Figure 2, right). Although participants' self-reports reflect the illusion, their manual behavior toward the visual objects responsible for the illusion is accurate and does not reflect what participants report. (For arguments against the notion of perception-action dissociations, see Franz, Gegenfurtner, Bülthoff, & Fahle, 2000, and Jeannerod, 2003. Stottinger and Perner, 2006, conclusively demonstrated the dissociation using an illusion [the diagonal illusion] that is free of the kinds of limitations found in previous experiments.) Thus, motor control is not influenced by the illusion. However, action selection is. If one had to choose which gang of vertical lines to fight in a street fight à la *West Side Story*, and one believed that longer lines were stronger than shorter lines, then one would choose to fight the gang on the right of Figure 2. Illusions are based on inborn or learned knowledge of the ventral stream. This knowledge constrains action selection but not motor control.

Constraining Dimensions

In conclusion, one should not equate conscious representations/processes with outputs. Rather, the evidence suggests that conscious representations are best defined as dimensions that constrain "voluntary" action-goal selection. For short, we refer to conscious representations as *constraining dimensions*, or "c-dimensions," a helpful abbreviation because the letter *C* reminds one that, by definition, the dimensions are both constraining and conscious. From this standpoint, that which is conscious reduces the space of possible skeletomotor action selection. Being aware of the presence of tasty food, a wall, the urge to scratch an itch, or a bright light all limit the degrees of freedom of possible skeletomotor action, whether one acts upon these kinds of information or not. (Again, it is important to note that "not acting" is still a form of action selection; Skinner, 1953.)

To advance the understanding of the interrelationships among the four distinct elements of the nervous system (inputs, unconscious processing, conscious processing, and behavioral outputs), it is fundamental to begin to define outputs and conscious representations/processes in terms other than their being just outputs or conscious, respectively. The current framework begins to do this by building on the integration consensus, SIT, and a reinterpretation of what an output is. In our framework, constraining dimensions are, by definition, conscious, but unlike the traditional (circular) definition of output, constraining dimensions are defined by more than their being conscious: They are also defined by their ability to *constrain integrated action-goal selection in the skeletal muscle output system*. They are not involved in intersensory conflicts, intrasensory conflicts, or the conflicts involving nonskeletal muscle effectors (Morsella et al., 2009a).

To best appreciate the role of constraining dimensions on behavior, one should consider the actions of a hypothetical, simplified mammal that, though conscious (for a treatment of basic consciousness in mammals, see Gray, 2004), is not equipped with many of the complicated abilities/states associated with humans (e.g., syntax, nostalgia, music appreciation), extra cognitive features that make it difficult to discern the basic function of constraining dimensions. At this stage of understanding and theory building, it is best to think of the role of constraining dimensions in the simplest situation involving the simplest possible organism. Hence, consider a manatee-like creature swimming through a Florida canal. It sees, in the distance, some plants that might make for a suitable dinner. At the same time, it perceives that near the plants is a large moving object (an alligator?). For reasons that it may not understand explicitly, the creature experiences both the urge to approach the food and the urge to avoid doing so, a classic *approach–avoidance* conflict (Lewin, 1935; Miller, 1959). At a minimum, the conflict slows down the creature's behavior. Action selection may be slower than usual.

Let us imagine further that, after experiencing conflict, the creature turns away and forsakes the potential food. This simple scenario reveals the intimate relationship between constraining dimensions and action. Had the creature experienced no conflict, perhaps its swimming rate would have remained unchanged. Had it been unconscious, efference–efference binding would have failed to occur, leading to unintegrated behavior (e.g., exhibiting the prepotent response). The example also underscores how thinking is for doing, counter to our natural human tendency to believe that conscious thinking is primarily for something higher than that of skeletomotor control. It is important to appreciate that the ultimate output of even our most lofty deliberations (e.g., which graduate school to attend) must eventually result in differential patterns of skeletomuscular activations (Sherrington, 1906). In the graduate school example, if the recruiting office for one university is to the west of one's house and the office for another university is to the east, then the decision about which school to attend will make one walk leftward or rightward when exiting the front door. In summary, *under normal circumstances, all decisions eventually "cash in" in different patterns of skeletomotor activation*. It is for this reason that the skeletal muscle output system has been referred to as the "final common path" of nervous activity (McFarland & Sibly, 1975; Sherrington, 1906).

Thus, through consciousness, representations and inclinations constrain the capacious possibilities of skeletomotor action selection. Consciousness therefore permits a form of integration that constrains the activities of the skeletal muscle effector, achieving a form of *multiple-constraint satisfaction* (Merker, 2007). (This form of multiple-constraint satisfaction may be an emergent property of re-entrant thalamocortical networks; Di Lollo, Enns, & Rensink, 2000.) In humans, constraining dimensions can be "online," reflecting stimuli in the current environment or, to a greater degree than in other animals, they can be "offline," reflecting covert processes such as memory, cultural knowledge, cognitive maps, operations on mental representations, and mental simulation (Schacter & Addis, 2007).

Within the field of consciousness, one constraining dimension may trigger another, which in turn triggers another, and so on and so forth. When the solution to a TOT state about someone's name enters consciousness many hours after one has given up searching for the name, consciousness of the forgotten name constrains immediate action selection, but it can also activate other constraining dimensions (Baddeley, 2007). For example, an emotional system may "react" with positive affect toward the name, only to then have another system react with negative affect (e.g., guilt) at the constraining dimension associated with the positive state. In this way, the conscious field is a constantly evolving state achieving continuous multiple-constraint satisfaction among action-related systems that would otherwise be encapsulated and influencing behavior independently. We emphasize that all this takes place along with incessant, ongoing unconscious processing and inferences. The organism yields an output (overt action) that can be construed as the outcome of a competitive senatorial-like process, one in which the interests and concerns of systems with different agendas, operating principles, and phylogenetic origins are constantly "represented." Unlike conflicts among real-life senators, intraorganism conflicts must be resolved, one way or another.

Constraining dimensions may be knowledge that is self-reportable but "imageless," such as the *imageless thought* associated with expectancies and "sets" (Woodworth, 1915). (Regarding imageless thought, Woodworth, 1915, concluded, "I know of no reason in neurology or psychology for supposing that the elements of conscious content are contributed solely by the sensory receiving centers" [p. 137].) For example, one may have the set to "be polite" at a dinner party or to "be fair" when judging others. Both sets are not composed by any obvious sensorimotor-like content, although they are self-reportable. These self-reportable dimensions constrain behavior and provide additional evidence for Sperry's view that constraining dimensions are more isomorphic to action (outputs) than they are to sensory inputs.

Origins of Constraining Dimensions

We continue with our example of consciousness as a phenomenon that is as atypical within the nervous system as modern GPS-based navigational systems are in today's automobile. It is clear that these navigational devices, and their "reverse engineering," do not reveal to us the basic principles of mechanized transport. As sophisticated as they may be (interacting with satellites and creating graphical "representations" of one's current driving environment, including traffic conditions), they are responsible neither for powering the car nor for conducting it. Just as automobiles could get from one place to another long before the advent of such systems, so did creatures express intelligent behavior before the advent of consciousness. The intelligentia of this "unconscious fauna" is still within each of us, and, like the engine and driver of a car, it is working behind the scenes as the prime mover of our behavioral repertoire, by influencing action directly (e.g., unconscious efference binding) or by furnishing the consciously experienced, constraining dimensions that influence action indirectly.

Being conscious of an urge does not imply that one knows the source of the urge. In our manatee example, the animal's constraining dimensions (its inclinations) may have been based on implicit cues. This occurs in humans. For example, in the phenomenon *blind-smell* (Sobel et al., 1999), the olfactory analogue of *blindsight* (Weiskrantz, 1992), people can learn to associate certain odorants (e.g., lavender) with certain environments (e.g., a particular room), even though the concentration of odorants presented during learning is consciously imperceptible (Degel, Piper, & Köster, 2001). At a more prosaic level, people tend to bathe more when lonely, apparently substituting physical warmth for the missing social warmth in their lives, but show no awareness of this influence on their bathing behavior (Bargh & Shalev, in press).

In short, one may consciously experience urges, intuitions, and predilections, but this does not mean that one knows the true source of such inclinations (Nisbett & Wilson, 1977).

Historically, to the question of where our intuitions and inclinations originate, "free will" or "the conscious mind" has been the answer, as given by Augustine, Descartes, and John Locke (see Bargh, 2007). However, given the documented existence of unconscious motivational, perceptual, and evaluative guides to appropriate action (see review in Bargh & Morsella, 2010), there is now an alternative answer to the question, for there is certainly no shortage of ideas or suggestions from our unconscious as to what to do in any given situation. As previously mentioned, that the unconscious mind does not suffer from a lack of behavioral expression or action control has long been known at lower levels of functioning. Consider that unconscious reflexes are controlled, sometimes in sophisticated ways (e.g., by feedback loops), and that the pupillary reflex is far from simple, though its mediation occurs unconsciously (Morsella, 2005). Licking, chewing, swallowing, and other behaviors can also occur unconsciously, given the appropriate stimulation (Bindra, 1974).

In any one situation, there are a multitude of behavioral impulses derived from our evolved motives and preferences, from our cultural norms and values, from our own past experiences in that situation, as well as from what other people are currently doing in that situation. These have afforded us unconsciously operating motives, preferences and their associated approach and avoidance behavioral tendencies, and mimicry and other "behavior priming" effects triggered by the mere perception of others' behavior (cf. Bargh & Morsella, 2010). The agentic systems that influence behavior directly (as in cases of unconscious efference binding) or indirectly (through subjectively experienced constraining dimensions) do not arise out of thin air: They are derived from action-related preferences that served adaptive and functional ends in the past. Knowledge gained through natural selection, the shortcuts, and other "good tricks" (Dennett, 1995) that consistently worked over our long-term evolutionary past is fed upward as a starting point—appearing to us as a priori knowledge, with no awareness of its source. Campbell (1974) called these "shortcut processes" because they save each of us individually from having to figure out from scratch which are the good and helpful things and which the dangerous and unhelpful things. These shortcut processes, according to Campbell as well as Dennett (1995), are the bases of our mysterious hunches and intuitions. Moreover, that these preferences and feelings are unconsciously generated is also consistent with the many demonstrations that we generally do not have good access to where our feelings come from and so can be easily fooled, and misattribute these feelings to some other plausible source (e.g., Schwarz & Clore, 1996; Wilson, 2002).

In summary, there certainly seems to be no shortage of suggestions from our unconscious as to what to do in any given situation. Evolution influences our preferences, and through them our tendencies to approach or avoid aspects of our environment. We are predisposed to prefer certain objects and aspects of our environment over others. Thus, we are often guided by our "feelings," "intuitions," and "gut reactions," which prioritize what is important to do or attend to (Damasio, 1996; Schwarz & Clore, 1996). Unconscious actional systems may seldom influence behavior directly, but they do influence action indirectly, through constraining dimensions.

Inclinations continue to be experienced consciously, even when they are not expressed behaviorally. Regardless of the adaptiveness of one's plan (e.g., running across hot desert sand to reach water), the strife generated by countering an evolved disposition (e.g., to avoid tissue damage) cannot be turned off voluntary (Morsella, 2005). One can choose to behaviorally endure a pain-for-gain scenario, but one cannot modulate the negative affect associated with it "at will" (Öhman & Mineka, 2001). It is important to note that inclinations can be *behaviorally suppressed* but not *mentally suppressed* (Bargh & Morsella, 2008). Thus, contrary to what intuition would lead one to believe, overt action is actually more flexible than the consciously-experienced constraining dimensions that often (but not always) influence it. Thus, constraining dimensions function like "internalized reflexes" (Vygotsky, 1962) which can be coopted to influence action selection. Accordingly, there is a consensus that conscious processes kick in after a behavioral impulse has occurred in the brain—that is, the impulse is first generated unconsciously, and then consciousness claims (and experiences) it as its own (Baumeister & Masicampo, 2010; Gazzaniga, 1985; James, 1890/1950; Libet, 1986; Wegner, 2002). These conclusions are consonant with the idea that, in phylogeny, *action preceded reflection* (Bargh & Morsella, 2008).

Although it is well documented that the principles of both respondent and operant conditioning fall short of explaining all forms of human behavior (cf. Chomsky, 1959; Lashley, 1951; Morsella, 2009; Tolman, 1948), it seems that these principles can explain much about the nature of constraining dimensions, especially how the dimensions arise in simple scenarios. It is somewhat ironic that, though Behaviorist principles have failed to explain their subject matter (behavior), they may actually be helpful in explaining the nature of consciousness, a topic that was outside the explanatory scope of Behaviorism. In fact, constraining dimensions reflect the kind of rigid stimulus-response contingencies that Behaviorists attempted to find in overt behavior but could not find. For example, perceiving a stimulus that has once generated great pleasure but that now should be avoided (e.g., a doughnut, cigarette) can engender approach inclinations that cannot be easily "turned off" at will (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Öhman & Mineka, 2001). As previously mentioned, one cannot influence the nature of the negative states associated with pain-for-gain scenarios (e.g., dieting or running across the hot desert sand to reach water). The Behaviorists were wrong in thinking that humans are in a state of always being compelled, functioning as strict $S \rightarrow R$ machines. Humans can also be inclined, but they are inclined in mechanistic ways.

As predicted by Sperry's perspective, the valence and other properties of constraining dimensions 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 (Morsella, 2005). It seems that the "inflexible" valence associated with a stimulus is best predicted by the principles of respondent and operant conditioning. The intricate and comprehensive model developed by the Behaviorists for understanding such a fictitious organism can explain much about the nature of constraining dimensions, which are intimately related to overt skeletomotor action. In short, constraining dimensions may be the mechanistic, inflexible entities that the Behaviorists framework sought to illuminate.

The organism is always highly constrained with respect to action selection. Consider action selection in dreams (e.g., Hobson, 1999). One of us (EM) recently had a dream in which he was a guest at a formal function and had to suppress uttering something that could be perceived as offensive to the host of the event. Regarding the degrees of freedom problem in action selection, because of the activated (and "imageless") set to be polite, the dream personage was able to suppress a strong action plan (a form of efference–efference binding). At the same time, however, the dream personage had no direct control with respect to turning off the inclination to say something (a second-level constraining dimension): The urge to say something persisted throughout the entire dream episode. In addition, the dream personage was very much bound by first-level constraints (e.g., the objects constituting the setting): In the dream scenario, it was highly unlikely that the dreamer would act as if he were at a soccer match rather than a formal event.

Interdimensional Dynamics

Having reviewed the liaison among outputs (actions), conscious states, and unconscious processing, we take a moment to consider how constraining dimensions interact with each other.

Data reveal that conflicting constraining dimensions have distinct behavioral, subjective, and neural effects compared to nonconflicting dimensions (cf. Morsella, Berger, & Krieger, in press). To the benefit of the experimenter, the kinds of interdimensional dynamics captured in our manatee example can be instantiated innocuously in the psychology laboratory, in *response interference* paradigms. In the classic Stroop (1935) task, for example, participants are instructed to name the color in which a word is written. When the word and color are incongruous (e.g., *red* presented in blue), response conflict leads to increased error rates, response times, and reported urges to make a mistake (Morsella et al., 2009a). This condition can be construed as eliciting efference–efference binding. When the color matches the word (e.g., *red* presented in red) or is presented on a neutral stimulus (e.g., a series of Xs as in "XXXX"), there is little or no interference (see review in MacLeod & MacDonald, 2000). (The neutral condition can be construed as a case of regular efference binding.) It has been proposed that, in the incongruent condition, there is conflict between word-reading and color-naming plans (Cohen, Dunbar, & McClelland, 1990). As predicted by SIT, which proposes that the primary function of consciousness is to integrate conflicting skeletomotor plans, the condition invoking incompatible action plans and efference–efference binding leads to the strongest perturbations. Similar effects are found in other response interference tasks (see quantitative review in Morsella, Berger, & Krieger, in press) and in paradigms in which participants sustain incompatible intentions (e.g., to point left and right with the same finger) in a motionless state (Morsella et al., 2009a).

Findings reveal an interesting interdimensional dynamic during the opposite of conflict, that is, when constraining dimensions are harmonious, as in the congruent condition of the Stroop task. In this condition, urges to err are low even though it is known that participants often read the stimulus word inadvertently: "The experimenter (perhaps the participant as well) cannot discriminate which dimension gave rise to the response on a given congruent trial" (MacLeod & MacDonald, 2000, p. 386). (For thorough treatments of this controversial issue, see Eidels, Townsend, & Algom, 2010, and Roelofs, 2010.) Urges to err in the congruent condition are comparable to those of the "neutral" condition of the Stroop task, in which the color is presented on an illegible letter string (Morsella, Wilson, Berger, et al., 2009b). In addition, in a within-subjects Stroop manipulation, "urges to read" were greater when words are presented in standard black font than when the same words were presented in a congruent color (Molapour, Berger, & Morsella, 2010), suggesting that the act of color-naming masks introspection of the reading process which may occur automatically (Morsella et al., 2009b). This finding has been explained as an instance of *double-blindness*, in which one is unaware that two distinct cognitive operations are activated when the operations lead to the same action plan (Morsella et al., 2009b).

In summary, when there is conflict among constraining dimensions, the organism experiences strong subjective perturbations; when there is congruence (or harmony) among the dimensions, the organism might not even know that two dimensions (or distinct underlying processes) were at play. Moreover, the organism may not know that distinct processes (some conscious and some unconscious) gave rise to its behavioral inclination or to its intuition. From this standpoint, an organism may not be able to discern whether a given intuition (e.g., a person's forgotten name) or inclination (e.g., which graduate school to attend) stemmed from a single unconscious process or from multiple, distinct processes leading to the same conclusion, as when color-naming and word-reading plans lead to the same action in the Stroop task. In this case, overt action is more isomorphic with the conscious state than with the inputs to the central processing. Sperry seems to be right again. (With great influence, Gibson, 1979, too proposed an "ecological theory" of perception in which perception is intimately related to action, but this approach is strictly nonrepresentational in that all the information necessary for action was provided and contained by the environment.)

Intuition: Another Constraining Dimension, Arising from the Unconscious and in the Service of Adaptive Action

By (a) reconceptualizing what is *the* output in the nervous system, (b) following Sperry's recommendation of working backwards from overt action to central processing, and (c) examining the nature of conscious contents, we have revealed the intimate liaisons among unconscious processing, conscious states, and action selection (perhaps the most challenging and important feat in the nervous system). This synthesis allows one to conclude that the "eureka-like" intuitions mentioned in our opening paragraph reflect not atypical brain processes but the general nature by which unconscious machinations constrain action, either directly or indirectly through the limited contents of consciousness, an atypical action-related process.

Although it is natural to experience amazement when a complex idea pops into mind without conscious invitation (Dijksterhuis & Nordgren, 2006; Helmholtz, 1856/1925), or when actions such as spoonerisms and action slips occur without one's consent, the scientific evidence allows one to appreciate that these events reflect the general nature of how the mind/brain works most of the time. Absent consciousness, creatures are not reduced to a mindless stupor, featuring no cogitation, behavior, or any semblance of being "alive"; the creatures simply lack one of the forms of action-selection control. As in the case of many intuitive judgments (e.g., that the sun revolves around the earth), our intuitions regarding the source of intelligent action are based on wrong assumptions. Consciousness is not necessary to produce action (e.g., as in unintegrated action); it is necessary only to constrain action in very specific ways.

One can conclude that Helmholtz was correct to use the term "unconscious inference" in a manner that is more inclusive than how it is used today. His example of unconscious inference during word reading is complemented by recent data revealing that, when confronted with a word stimulus, experimental participants cannot help but experience the urge to read the word (even though they may suppress uttering the word). As in the case of blind-smell and double-blindness, participants may or may not be able to infer the unconscious sources of these and other conscious inclinations, representations which historically have been incorrectly construed as the "outputs" in the nervous system. As posited by Helmholtz, most of the contents of that atypical and well-circumscribed brain process known as consciousness are the product of some kind of unconscious inference, from inborn or learned knowledge. In short, there is no shortage of unconscious sources to guide action selection, either directly or indirectly.

One of our aims was to recharacterize conscious contents as being more than "outputs" and more than "conscious." Upon close inspection and after integrating knowledge from ideomotor theory, the integration consensus, SIT, and other sources (e.g., the requirements of broadcasting "isotropic information"; Fodor, 1983), it is clear that these contents are intimately related to a specific form of *integrated action-goal selection in the skeletal muscle output system* (Figure 1), one that is assciated with the ventral pathway and is dissociated from low-level, input processes (e.g., subphonemic contrasts) and motor control (Figure 2). Some of the contents reflect first-level constraints (e.g., how the organism should negotiate physical objects), whereas others reflect second-order constraints (e.g., based on needs), including sophisticated intuitions (e.g., which graduate program to attend). In any case, as Sherrington (1906) noted, the aim is always to activate the right muscles at the right time.

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Note

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