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The Prospective Nature of Voluntary Action: Insights From the Reflexive Imagery Task

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Voluntary action is peculiar in several ways. For example, it is highly prospective in nature, requiring the activation of the representations of anticipated action-effects (e.g., a button pressed). These *prospective action-effects* can represent outcomes in the short-term (e.g., fingers snapping or uttering "cheers") or in the long-term (e.g., building a house). In this review about the prospective nature of voluntary action, we first discuss in brief *ideomotor theory*, a theoretical approach that illuminates both the nature of the prospective representations in voluntary action and how these representations are acquired and subsequently used in the control of behavior. In this framework, prospective action-effects could be construed as 'action options' that, residing in consciousness, may or may not influence upcoming behavior, depending on the nature of the other prospective action-effects that happen to be coactivated at that time. In ideomotor theory, there is no homunculus that selects one prospective action-effect over another. Many of these prospective action-effects enter consciousness automatically. Second, we introduce the principle of atemporality and discuss the prospective nature of *determining tendencies* and mental simulation, all in the context of new findings from the Reflexive Imagery Task (RIT). The RIT reveals that, as a function of external control, prospective action-effects can enter consciousness in a reflex-like, automatic, and insuppressible manner. The RIT and its associated theoretical framework shed light on why the activation of such representations, though often undesired, is nonetheless adaptive and why not all of these prospective representations lead to overt action.

Keywords: consciousness, ideomotor theory, prospective cognition, reflexive imagery task, voluntary action

In response to a salient stimulus (e.g., a flash of light), the human organism can emit a variety of responses. These responses can arise from various effector systems, including the smooth muscle effectors (e.g., the pupillary reflex), the visceral/endocrine systems (e.g., the skin conductance response), and the skeletal muscle system. All these responses can arise simultaneously. Actions stemming from the skeletal muscle system can be unintentional, as in the case of the movements of the limbs, head, and torso in the startle reflex and the *orienting response* (Sechenov, 1863/1965), or they can be voluntary, as when one decides to fix one's gaze on a bright light. Consideration of all the varied effector response systems and their many ways of operating (e.g., automatically vs. intentionally) allows one to appreciate that behaviors falling under the rubric of 'voluntary' action form only a subset of the entire behavioral repertoire of the organism and that these behaviors are peculiar in several ways.[1] For instance, of all the response systems, these behaviors could be regarded as being the most prospective in nature. As discussed below, voluntary action cannot arise without prospective cognitions about future behavioral outcomes ("prospective action-effects," for short). Moreover, to a degree greater than that of any other effector system, the system responsible for voluntary action must take into account potential outcomes occurring, not only in the immediate future, but also in the long term (e.g., when planning to earn an academic degree). No other response system is as forward-looking.

In this review about the prospective nature of voluntary action, we first discuss in brief *ideomotor theory*, an influential theoretical approach that illuminates both the nature of the prospective representations in voluntary action and also how these representations are acquired and used in the control of future behavior (see review of ideomotor theory in Shin, Proctor, & Capaldi, 2010). Ideomotor theory is consistent with new theoretical frameworks that provide novel ways of thinking about the relationship between conscious representations and the control of overt action. In these frameworks, these representations are construed as "options" for actions in the near or distant future. Second, we discuss the prospective nature of *determining tendencies* (Ach, 1905/1951) and the *prepared reflex* (Ach, 1905/1951; Cohen-Kdoshay & Meiran, 2009;

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[1] Because voluntary actions are consciously mediated, one tends to be more aware of their occurrence than of the occurrence of other kinds organismic responses (e.g., smooth muscle responses). This might lead one to underestimate the rate of occurrence of the latter. Voluntary actions are intimately related to the sense of self, the sense of agency, and consciousness (discussed below).

Exner, 1879; Gollwitzer, 1999; Hommel, 2000; Woodworth, 1939) in the context of findings from a new experimental paradigm (the Reflexive Imagery Task [RIT]; Allen, Wilkins, Gazzaley, & Morsella, 2013). The paradigm reveals, among other things, the nature in which prospective action-effects can enter consciousness as a function of the combination of external stimuli and determining tendencies.

The Prospective Nature of Ideomotor Processing

Prospective Action-Effects

Voluntary action requires the activation of prospective action-effects. As James (1890) concludes, before performing a voluntary action (e.g., making a toast at a dinner party), one must have an idea of what that action is to be. These representations are, not of the action itself, but rather of the perceptual consequences in the world (or in the body) of the action having been expressed (James, 1890). For example, these representations could be of a light switch being set to the "off" position, of a word being uttered, of fingers snapping, or of a soccer ball being put into the net. (Harleβ [1861] referred to these anticipated, perceptual consequences of voluntary action as the *Effektbild*, meaning, "the picture of the effect." It is important to appreciate that Harleβ's Effektbild is a prediction of sorts—a prediction of what will arise in the world as the result of a to-be-produced behavior.) Motorically, these representations concern the "final end state" and can be realized in multiple ways, as in the case of *motor equivalence* (Lashley, 1942), in which several different motor acts can lead to the same end state. For example, an object could be moved rightward by motions of the back of the hand or by motions of the elbow. Skinner (1953) characterized these goal-directed acts, which could be realized motorically in various ways, as *operants* (pp. 14–15). These prospective representations of action-effects can represent outcomes in the short-term (e.g., hearing oneself utter "cheers") or in the long-term (e.g., building a house). (In this review, we focus on the former; for a treatment of the latter, see Morsella, Ben-Zeev, Lanska, & Bargh, 2010.)

Importantly, prospective action-effects are isomorphic (i.e., similar in form) to what would be observed if the action were produced. For example, hearing oneself utter "house" is isomorphic in some way to what one experiences during the subvocalization of the word. (Subvocalization occurs when one says a word, not aloud, but 'in one's head.') Thus, prospective action-effects are based on the previously experienced, perceptual consequences of the action. These representations are perceptual in nature. For example, it has been proposed that, in subvocalization, corollary discharge from motor centers to perceptual centers provides the sensory content for this kind of inner speech (Scott, 2013). (For evidence that voluntary action is controlled by perceptual-based representations, see Badets & Osiurak, 2015; Mechsner, Kerzel, Knoblich, & Prinz, 2001.) Often, the representations are memories of action effects that first arose unintentionally and that did not arise by prospective, ideomotor mechanisms (Hommel & Elsner, 2009). Hence, memory is essential for this kind of prospective processing. As James (1890, p. 487; cited in Hommel & Elsner, 2009) notes, "If, in voluntary action properly so-called, the act must be foreseen, it follows that no creature not endowed with divinatory power can perform an act voluntarily for the first time."

The process of acquiring knowledge of action effects, whose activation later leads to the production of the associated action, can be construed as the acquisition of an *inverse internal model* (Wolpert & Kawato, 1998; cited in Melcher et al., 2013), in which the external effects produced by the motor system must match the anticipated goal representation of the action. (The neural correlates of ideomotor learning provide further evidence that this form of learning is highly prospective in nature.[2]) That action is controlled by prospective representations of potential (perceptual-based) action effects contributes, not only to one's foreknowledge about the nature of future action, but also to the detection of motor errors (Adams, 1971; Badets & Osiurak, 2015; Schmidt, 1975), which could be construed as mismatches between expected and actual action outcomes. In short, prospective action-effects require memory and are in a perceptual-like format (see Morsella, Godwin, Jantz, Krieger, & Gazzaley, 2015, for discussion regarding why this is the required format for adaptive action selection).

The Direct Link Between Prospective Action-Effects and Overt Action

The notion of the ideomotor mechanism[3] is simple but deep and far-reaching. The basic idea is that the activation of a prospective action-effect triggers the execution of the action that will give rise to that effect. More specifically, James (1890) concludes that, when ideomotor mechanisms generate action, the activation of the Effektbild leads to the corresponding action—effortlessly, automatically, and, importantly, without any knowledge of the motor programs involved. (For a treatment of why motor programs must be unconscious, see Grossberg, 1999; Jeannerod, 2006; Prinz, 2003.) From this standpoint, the mental image of, say, flexing one's finger will trigger the flexing of that finger, automatically. Again, these prospective representations can be of a communicative act (e.g., uttering a word), of bodily effects (e.g., a finger flexing), or of 'remote' effects in the world (e.g., a button being pressed). Ideomotor processing is illustrated clearly in the following anecdote (mentioned in Berger & Morsella, 2012; and in Morsella, Molapour, & Lynn, 2013). The TV program *60 Minutes* presented news coverage of how patients can today control robotic arm/limb prostheses. In the episode, the interviewer of the TV program was surprised to learn that a soldier who had lost his

[2] This form of learning has been associated with activities in several brain regions, including the hippocampus, parahippocampal gyrus, caudate nucleus, and angular gyrus (Elsner et al., 2002; Melcher, Weidema, Eenshuistra, Hommel, & Gruber, 2008; Melcher et al., 2013). Important for the present purposes, some of these regions (e.g., hippocampus) have been shown to be essential for prospection and for the simulation of future, potential behaviors (Schacter & Addis, 2007). Some of these regions (e.g., hippocampus) are also associated with declarative, *relational memory*, which is certainly an element of ideomotor learning. For instance, in ideomotor learning, one must associate, through relational memory, discriminative stimuli (e.g., a lever) and action effects. Other brain regions associated with ideomotor learning have been linked to operant conditioning (e.g., the caudate nucleus; Melcher et al., 2013), which is necessary for the acquisition of instrumental actions such as pressing a button for a reward.

[3] The notion of ideomotor processing was introduced by Lotze (1852; see similar theorizing in Carpenter, 1874), and further developed by Harleβ (1861) and James (1890). James (1890) eloquently popularized the idea in his treatise on voluntary behavior (see contemporary ideomotor approaches in Greenwald, 1970; Hommel, Müsseler, Aschersleben, & Prinz, 2001).

lower arm in combat could, in just a few practice trials, control the grasping motions of a robotic hand. This prosthesis was connected to electrodes attached to the muscles of the spared part of the upper arm. Importantly, the soldier had never before interacted with the robotic arm. The interviewer asked the soldier how could it be that he knew which muscles to activate to enact the robotic action. The soldier replied that he had no idea regarding what the muscles were doing, nor which muscles to activate. Instead, the soldier claimed that, to enact the action on the part of the robotic arm, all he had to do was imagine what the grasping action would look like (a prospective action-effect). This imagery was somehow translated (unconsciously) into the kind of muscular activation that normally results in the grasping action. Motor control, though unconscious, is itself highly prospective in nature (Berthoz, 2002), as is evident in the phenomena of coarticulation (Levelt, 1989) and end-state comfort (Zhang & Rosenbaum, 2008). (For evidence regarding the conscious impenetrability of motor programming, see Fecteau, Chua, Franks, & Enns, 2001; Fourneret & Jeannerod, 1998; Heath, Neely, Yakimishyn, & Binsted, 2008; Jeannerod, 2006; Liu, Chua, & Enns, 2008; Rossetti, 2001.)

If motor programming is mediated unconsciously, and if no memories are formed for these unconscious programs (which are executed online and then "scrapped"; Grossberg, 1999; Rosenbaum, 2002), then it becomes apparent why voluntary action, which, as James notes (1890), requires the memories associated with past actions, must rely so heavily on perceptual-like representations. Simply put, the conscious mind, in the control of action, has little else to access (see Morsella et al., 2015, for further discussion). Hence, during the generation of speech, prospective action-effects can reflect only, not the articulatory code of a word (which is motor-related and unconscious) but the phonological code, which is perceptual-like. With this in mind, one can appreciate that corollary discharge for speech and for other actions is prospective in more ways than one. First, it concerns potential, to-be-produced actions (i.e., actions that are not yet expressed). Second, its format, which is perceptual in nature, reflects, not motor programs, which are responsible for engendering actions, but the downstream consequences of the expression and effects of those programs.

Regarding the link between prospective action-effects and overt action, contemporary ideomotor theories (e.g., Hommel, Müsseler, Aschersleben, & Prinz, 2001; Hommel, 2009) propose that ideomotor effects arise because perceptual and action codes (for expressed or potential actions) activate each other by sharing the same representational format ('common coding': Hommel et al., 2001).[4] (This theorizing is in accord with research on *mirror neurons*.[5]) This hypothesis is supported by many experimental findings, including *stimulus-response* (*S-R*) compatibility effects. In these effects, an action is facilitated when it is in some way similar to the percept that gave rise to it. For example, responses are faster with the left hand if an auditory stimulus happens to be presented to the left ear rather than to the right ear, the Simon effect (Simon, Hinrichs, & Craft, 1970). Similarly, if one is trained to press a button on the left when presented with a square and to press a button on the right when presented with a triangle, one will be faster to respond to the square if it happens to be presented on the left (vs. right) and be faster to respond to the triangle if it happens to be on the right (vs. left). As is clear in these examples, compatibility effects arise even when the location of the stimulus is task-irrelevant. These approaches also propose that mimicry and observational learning can arise from ideomotor mechanisms, because Effektbilds can be acquired vicariously. For example, one might see someone perform a peculiar action (e.g., twirling a stick or uttering a nonsensical word [e.g., PHIM]) and passively acquire the perceptual representations of these events. Afterward, long into the future, one might reactivate these representations in the mind in order to execute these motor acts, without any knowledge of the underlying motor programming.

The strong link between perception (or mental imagery) and action is evident in neurological conditions. For example, there is the case of the patient who, suffering from lesions of the parietal lobe, was incapable of suppressing the expression of imagined actions (Schwoebel, Boronat, & Branch Coslett, 2002). In other neurological conditions, such as ambient echolalia, patients cannot suppress repeating aloud the words that they happen to hear (Suzuki et al., 2012). From an ideomotor standpoint, it could be argued that, in these cases, prospective action-effects were not sufficiently suppressed (discussed in the next section). Additional evidence of a direct link between perception and action planning stems in part from *response interference* paradigms such as the Stroop task (Stroop, 1935) and the Eriksen flanker task (Eriksen & Schultz, 1979). In these paradigms, action-related cognitions and incidental action-related stimuli do indeed activate motor programs (to some extent), even when the actor does not wish to express such plans. For example, psychophysiological evidence reveals that, during response interference, competition involves simultaneous activation of the brain processes associated with both

[4] In ideomotor-based approaches, most ideomotor effects can be categorized as reflecting one of two phenomena: The *perceptual induction* of action, in which people perform the actions that they observe, and the *intentional induction* of action, in which people perform the movements that they would like to see occur (Knuf, Aschersleben, & Prinz, 2001). For the latter, there is anticipatory imagery concerning the potential action. Classic examples of intentional induction are found in bowling or golf, in which players often sway their bodies in the direction in which they would like the ball to move (Knuf et al., 2001). However, if a player swayed his body in the direction that the ball was actually moving, then it would be a case of perceptual induction. In both cases, there is an isomorphism between a representation (perceptual vs. goal-like) and some action.

[5] Mirror neurons (see review in Rizzolatti, Sinigaglia, & Anderson, 2008) become active both when one perceives an action and when one engages in that action (Frith & Wolpert, 2003; Meltzoff & Prinz, 2002). Consistent with ideomotor theory, mirror neurons fire with respect to motor goals rather than with respect to the movements that realize these goals. Thus, these neural events seem to be more related to encoding end-state representations (Ashe et al., 1993; Iacoboni & Dapretto, 2006; Rizzolatti, Fogassi, & Gallese, 2004). Ideomotor theory is also relevant to common coding theories of speech perception (e.g., Liberman & Mattingly, 1985), in which perception relies in part on the motor codes used to produce speech—*sounds perceived as alike are produced as alike* (Galantucci, Fowler, & Turvey, 2006; Pickering & Garrod, 2007). See recent evidence for motor theories of speech perception in Schomers, Kirilina, Weigand, Bajbouj, and Pulvermüller (2015); see challenges to these motor approaches in Georgopoulos (2002); Hickok (2009); Mahon and Caramazza (2008), and Sheerer (1984). Mahon and Caramazza (2008) point out a potential fallacy of motor theories of mental representation—the incorrect assumption that the consistent activation of circuit or region *x* (e.g., a motor region) during process *y* (e.g., object naming) implies that region *x* constitutes process *y*. It may be that activation of region *x* is an incidental by-product of the activation of *y*, or that the activation of region *x* reflects that the person is preparing to respond in some way to the representations associated with *y*.

intended (selected) and unintended (unselected) action plans (Coles, Gratton, Bashore, Eriksen, & Donchin, 1985; Eriksen & Schultz, 1979; DeSoto, Fabiani, Geary, & Gratton, 2001; Mattler, 2005; McClelland, 1979; van Veen, Cohen, Botvinick, Stenger, & Carter, 2001).

Conflict Between Prospective Action-Effects

At first glance, the notion of ideomotor processing appears at odds with our everyday experience: It is not the case that we act out every prospective action-effect that enters our consciousness. So how can ideomotor theory be on the right track? In response to this observation, it is important to appreciate that, according to James, the mere thoughts of these action effects 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 (James, 1890, pp. 520–524). Lotze and James's "acts of express fiat" refer, not to a homunculus reining in action, but rather to the effects of the activation of another, competing prospective representation (i.e., a competing action plan):

> According to Lotze, to carry out a voluntary action, two conditions must be fulfilled. First, there must be an idea or mental image of what is being willed (*Vorstellung des Gewollten*). Second, all conflicting ideas or images must be absent or removed (*Hinwegräumung aller Hemmungen*). When these two conditions are met, the mental image acquires the power to guide the movements required to realize the intention, thus converting ideas in the mind into facts in the world. (Prinz, Aschersleben, & Koch, 2009, p. 38)

Thus, the reason why in everyday life we do not enact all of the prospective action-effects that we happen to imagine is because such actions are prevented by the simultaneous activations of incompatible prospective action-effects. In this framework, and consistent with neural evidence,[6] there is no homunculus needed to select one prospective action-effect over another: At one moment in time, Action *A* will compete with Action *B*; at another moment in time, Action *C* will compete with Action *D*, without the need of an omnipresent "decider." (See relevant, highly developed model of "countermanding" in Logan, Yamaguchi, Schall, & Palmeri, 2015.)

Prospective Action-Effects as "Action Options"

Ideomotor theory is complemented by recent theoretical approaches (e.g., Krisst, Montemayor, & Morsella, 2015; Morsella et al., 2015; Merker, 2013) in which the contents composing the conscious field (including prospective action-effects) are construed as "action options," both those which are selected to influence overt behavior and those which are not selected. (These recent ideas are based in part on Jamesian *functionalism* [see discussion in Morsella, Hoover, & Bargh, 2013] and Gibson's [1979] notion of affordances; they are also consistent with Sechenov's [1863/1965] idea that action-related thoughts could be construed as inhibited actions.) Accordingly, from a Jamesian, ideomotor perspective (James, 1890), a subvocalization is construed as a suppressed verbalization (see also Vygotsky, 1962). Consistent with this conclusion, in the speech production literature, subvocalizations are regarded as prospective, 'prearticulatory outputs' (Levelt, 1989; Slevc & Ferreira, 2006), a term that conveys the intimate link between this kind of conscious representation and potential overt action (Morsella & Bargh, 2010). In these models of speech production (e.g., Slevc & Ferreira, 2006), some of which are based on the study of the neural correlates of subvocalization,[7] these prearticulatory outputs (subvocalizations) are monitored and "checked" before articulation takes place. Often, these subvocalizations are experienced consciously but are not uttered, as when one, after seeing some stimulus, thinks of something funny to say but, out of a sense of decorum, refrains from saying anything aloud. Similarly, one might see a baby and then hear in one's mind "goo goo ga ga" – a potential, to-be-uttered phrase that one may or may not utter aloud, depending on the context (e.g., whether the baby is awake or sleeping). The phonological representation of "goo goo ga ga," a prearticulatory output, could be construed as an action option for future behavior. As discussed above, if one were to utter the phrase aloud, then the perception of one's own speech would be isomorphic in several ways (e.g., phonology) with the mental imagery of the to-be-uttered phrase (MacKay, 1992).

[6] Additional evidence for ideomotor processing stems from research on the neural correlates of action conflicts. During action conflicts, no single area of the brain is responsible for the inhibition of all actions (Curtis & D'Esposito, 2003, 2009). Thus, during conflict, there is no brain activity corroborating what we intuitively believe—that there is a homunculus reining in one action and selecting another action. Instead, one conflict will involve competition between brain circuits *A* and *B* (Logan et al., 2015), and another conflict will involve competition between circuits *C* and *D*. Importantly, both conflicts share no common, "general inhibition" region: The conflicts involve only the dynamics between representations (Hubbard, Rigby, Godwin, Gazzaley, & Morsella, 2013). Thus, there is no neural evidence for the existence of an omnipresent observer or "decider" (see discussion in Montemayor, Allen, & Morsella, 2013). See additional neural evidence for the lack of such an omnipresent observer in Guggisberg, Dalal, and Nagarajan (2009).

[7] Because controversy continues to surround the identification of the neural correlates of the phonological representations that are activated by heard, spoken speech (e.g., Hickok, 2009; Schomers et al., 2015), strong claims cannot yet be made regarding the neural correlates of subvocalized speech (Buchsbaum, 2013; Buchsbaum & D'Esposito, 2008). It seems that the neural correlates of phonological representations involve the left superior temporal cortex (including the superior temporal gyrus and sulcus) and a medley of other regions (supramarginal gyrus, inferior frontal gyrus, and precentral gyrus; DeWitt & Rauschecker, 2012; Eggert & Wernicke, 1874/1977; Gazzaniga, Ivry, & Mangun, 2014; Peramunage, Blumstein, Myers, Goldrick, & Baese-Berk, 2011). Buchsbaum (2013) concludes that subvocalized speech is often associated with activations in both motor-related regions in frontal cortex, such as the inferior frontal gyrus (for phonological planning) and the precentral gyrus (for motor programming), and in perception-related regions that are associated with speech perception (e.g., superior temporal sulcus). Accordingly, Scott (2013) presents evidence that, during subvocalization, corollary discharge provides the conscious sensory content of one's inner speech (Ford, Gray, Faustman, Heinks, & Mathalon, 2005). It remains controversial whether subvocalized speech requires the activation of motor-related regions or whether subvocalized speech and other forms of auditory imagery can arise without these activations (Hickok, 2009; Schomers et al., 2015; see discussion in Buchsbaum & D'Esposito, 2008, and in Mahon & Caramazza, 2008). Today, there is no clear evidence that lesions to motor areas associated with speech production eradicate the capacity for subvocalizing or for other kinds of verbal imagery on the part of the patient (cf. Gruber, Gruber, & Falkai, 2005; Müller & Knight, 2006; Sato et al., 2004; Vallar, Corno, & Basso, 1992; for some evidence of a necessary, causal role of motor areas in speech perception, see Schomers et al., 2015).

Encapsulation of Prospective Action-Effects

Our subvocalization examples reveal that prospective action-effects are often activated automatically, by the mere presence of external stimuli. Consistent with this observation, some theorists (e.g., Freud, 1938; James, 1890; N. E. Miller, 1959; Vygotsky, 1962; Wegner, 1989) suggest that the activation of most conscious contents, including prospective action-effects, may be more susceptible to external control than previously thought (see review in Allen et al., 2013). For example, Helmholtz (1856/1925) proposes that entry into consciousness can be triggered in a seemingly reflexive manner because of the many *unconscious inferences* underlying the generation of conscious contents (e.g., for depth perception, color constancy). Although unconscious, these inferences are sophisticated in nature. One is conscious only of the products of these complicated processes but not of the processes themselves (Lashley, 1958; G. A. Miller, 1962). Importantly, these inferences are hypothesized to be responsible not only for the generation of basic conscious contents, as in perception (e.g., depth perception, Emmert's Law), but also for more complex contents such as the consciously experienced phonological representations associated with automatic word-reading.[8]

Theorizing about unconscious inferences and the conscious contents they generate is complemented by the notion that conscious contents stem from 'encapsulated' processes (Firestone & Scholl, 2014; Fodor, 1983; Krisst et al., 2015; Pylyshyn, 1984). Perceptual processes giving rise to illusions are often said to be encapsulated because one's knowledge about the true nature of the perceptual stimuli (e.g., that the two lines of the Müller-Lyer illusion are equal in length) cannot terminate the illusions. In action control, urges, too, are often encapsulated. For example, when holding one's breath while underwater, or when running barefoot across the hot desert sand to reach water, one cannot directly influence the generation of the inclinations to inhale or to avoid touching the hot ground, respectively (Morsella, 2005). The action-related conscious contents, which can be construed as prospective action-effects, are triggered by these stimulus environments and cannot be weakened or eliminated by the actor's beliefs or desires, even when doing so would be adaptive (Morsella, 2005; Öhman & Mineka, 2001). Although inclinations triggered by external stimuli are *behaviorally suppressible*, they are often not *mentally suppressible* (Bargh & Morsella, 2008; Morsella, 2005).

According to some theorists (Baumeister, Vohs, DeWall, & Zhang, 2007; Firestone & Scholl, 2014; Krisst et al., 2015; Merker, 2013; Pylyshyn, 1984), the kind of encapsulation associated with the generation of prospective action-effects is (a) built into the system, with content generators "not knowing," in a sense, what other content generators are introducing into the conscious field (Morsella, 2005); and (b) adaptive, for most conscious contents *should be* encapsulated. For example, it would not be adaptive for contents pertaining to incentive/motivational states to be influenced directly by other contents, such as desires and beliefs: If one's desires or beliefs could lead one to voluntarily terminate feelings of guilt, hunger, nausea, or pain, then these states would lose their adaptive value (Baumeister et al., 2007). These views concerning the encapsulated nature of content generation may illuminate some aspects of psychopathological phenomena (e.g., in obsessions and intrusive cognitions; Magee, Harden, & Teachman, 2012; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). This theorizing also illuminates why Chomsky (1988) observes that humans, unlike machines, are not only *compelled* to act one way or another but can also be only *inclined* to act a certain way. It is because the inclinations cannot be turned off and because not all prospective action-effects are destined to influence overt behavior.

Simulations of Future Actions

It is interesting to consider that, whether a future action is to be expressed in a few moments (e.g., to make a toast after the champagne has been served) or in several years (e.g., the idea of what one will say in one's retirement speech), the representational format for the prospective action-effect is similar in nature (e.g., being perceptual-like). (But see Trope & Liberman, 2003, for a treatment of how the variable of time-span influences the way one thinks about future events.) This stems in part, again, from the fact that the systems that generate the prospective action-effects that form part of the conscious field do not, in a sense, "know" whether they are relevant to ongoing action. Moreover, whether the action is to unfold now or long into the future, both the nature of the prospective action-effects and one's evaluations of them are similar in nature. To appreciate this, one must first consider the nature of suppressed actions and mental simulation.

Early in development, behaviors tend to reflect the actions of what can be construed as an 'unsuppressed' cognitive apparatus. For example, a toddler would fail to continue to carry a hot object, just as infants routinely fail to suppress elimination behaviors or to endure an aversive state for some reward. Later in development, however, operant learning assumes a greater influence on the behavioral repertoire, and actions begin to reflect suppression. In ideomotor terms, a previously dominant action effect is now checked by an incompatible action-effect. Hence, action plans that had been expressed reflexively become capable of being suppressed. This leads to the *suppression of an action program*, which often engenders intrapsychic conflict, which is experienced as having an aversive, subjective cost (Dreisbach & Fischer, 2015; Lewin, 1935; Morsella, 2005). Faced with suppression, prospective action-effects no longer influence behavior directly, though they still influence the nature of subjective experience: Inclinations are experienced subjectively, regardless of whether they are expressed behaviorally (Bargh & Morsella, 2008). In this way, prospective action-effects can function as internalized reflexes (Vygotsky, 1962), which is consistent with Sherrington's (1941) definition of pain as, "the psychical adjunct of an imperative

[8] In paradigms such as the Stroop color-naming task (Stroop, 1935), processes such as automatic reading engender, not only the phonological forms associated with the orthograph (Augustinova & Ferrand, 2014), but also conscious urges to read the word aloud (Molapour, Berger, & Morsella, 2011; Morsella, Gray, Krieger, & Bargh, 2009; Morsella, Wilson, et al., 2009), revealing, again, the intimate link between conscious contents and action in the RIT. Participants may perceive goal-irrelevant urges as less associated with their sense of self when the plans conflict with intended action than when the same plans lead to no such interference (Riddle, Rosen, & Morsella, 2015). This is consistent with the "monkey on one's back" metaphor describing aspects of addiction. From this standpoint, urges (e.g., to smoke) conflicting with current goals (e.g., to not smoke) tend to be perceived as foreign to the self (Morsella, Berger, & Krieger, 2010). In these paradigms, response interference is also associated with weakened *perceptions of control* and stronger *perceptions of competition* (Riddle et al., 2015).

protective reflex" (p. 286). According to Bargh and Morsella (2008), in the mental simulation of potential future actions (including the consequences of these actions), these internalized reflexes can be coopted to play an essential, evaluative role, as we shall now explain.

A good way of knowing the consequences of a course of action is by simulating it. One benefit of such simulation is that knowledge of an action outcome is learned without the risks of performing the action (Barsalou, 1999). (Some theories propose that the function of explicit, conscious memory is to simulate future, potential actions; Schacter, & Addis, 2007.) Importantly, simulacra (i.e., the products of simulation) are worthless without the capacity to somehow evaluate them. Simulation can construct simulacra (e.g., certain action effects), but it by itself cannot evaluate them. In humans, evaluating a potential course of action is particularly challenging because whether a particular course of action is worthy of being taken often depends on a plethora of diverse considerations (e.g., physical, nutritional, or reproductive factors). Hence, Bargh and Morsella (2008) propose that simulation requires an additional process that (somehow) possesses enough knowledge to evaluate the simulacra of potential action effects with respect to innumerable considerations.

Bargh and Morsella (2008) go on to propose that the aforementioned suppressed action-effects, which have been characterized as internalized reflexes, provide this evaluative judgment. From this standpoint, one immediately has a sense of whether a simulated bodily action outcome is desirable, although such a judgment takes many considerations into account. For example, one might simulate the act of carrying a large mirror on a recently mopped floor and experience, in response to this simulation, a gut feeling hinting that such a course of action would be unsafe. Similarly, one might simulate saying something funny at one's retirement speech only to then realize that such a comment might not be funny to certain, say, overly formal coworkers. Accordingly, research has shown that, faced with action options, people experience inexplicable gut feelings (or 'somatic markers'; Tranel & Damasio, 1985) reflecting the inclinations of action-related systems whose inner workings and learning histories are unconscious (Öhman & Mineka, 2001). When these systems function abnormally, action selection is compromised, as in the historical case of Phineas Gage (cf., Damasio, 1994).

The Principle of Atemporality

It has been proposed that a given combination of prospective action-effects in the conscious field, whether triggered by external stimuli or by simulation, will always, in principle, yield the same outcome regarding action selection (Morsella et al., 2015). For example, all things being equal and with normal motor function, the combination of prospective action-effects *X*, *Y*, and *Z* will always yield the selection of action *Z* (or, more precisely, of "operant" *Z*). To return to our examples, one would *always* have a negative gut feeling about carrying a mirror on a freshly mopped floor or about saying a funny statement in the presence of certain coworkers, whether the acts were to be done in the next five minutes or long into the future. Hence, whether prospective action-effects are triggered by the stimuli composing the present environment, or by mental simulations of action for the near or distant future, the same collection of prospective action-effects will always yield the same outcome regarding action-selection. We refer to this as the *principle of atemporality*. As explained above, this principle stems in part from the notion (Morsella et al., 2015) that prospective action-effects, as conscious contents, do not, in a sense, "know" whether they are relevant to ongoing action or to the other contents composing the conscious field. From this standpoint, just as the eye does not turn off when there is nothing interesting to look at, the conscious field is always "on," passively representing its many contents, including prospective action-effects that happen to be activated at one moment. Similarly, the cognitive architecture underlying ideomotor processing is continuously "on," with all percepts incessantly priming potential action plans (Jordan, 2009, 2013). (Such a mode of operation could be explained by nonrepresentationalist, dynamicist accounts; see Gibson, 1979; Jordan, 2013.)

In Morsella et al. (2015), the conscious field, though occupied across time by varied configurations of prospective action-effects, has what can be regarded as a fixed architecture with few "moving parts." From this standpoint, what consciousness does is more akin to the (relatively passive) manner of operation of the eye than of, say, a vending machine, in which the manner of operation varies depending on the inputs (e.g., the buyer's selection of E4 vs. J2) and certain conditions (e.g., receiving an incorrect vs. correct amount of money).

Importantly, the principle of atemporality suggests also that the same medley of prospective action-effects in the conscious field will yield the same subjectively experienced intrapsychic conflicts, regardless of whether these representations are activated by external stimuli or by working memory (Hubbard et al., 2013). Hence, people may avoid certain simulations regarding the selection of action for certain future settings.

Determining Tendencies and the Prepared Reflex

Prospective action-effects can enter consciousness in various ways. One way would be for the perception of a stimulus to activate such a representation in consciousness, as in our "goo goo ga ga" example. As discussed above, it is clear that, on many occasions, such prospective action-effects can enter consciousness involuntarily. For example, while at the dinner table, a cue might trigger into consciousness, out of the blue, a funny phrase to utter aloud. In many circumstances, stimuli activate these representations in a direct, automatic manner, although behavior is not influenced in this direct way. Again, inclinations triggered by external stimuli are *behaviorally suppressible*, but they are often not *mentally suppressible* (Bargh & Morsella, 2008; Morsella, 2005). (But see Johnson & Raye, 1981, about differences between real and imagined events.)

Stimuli in the environment could also trigger covert, self-talk about future tasks (Morsella, Ben-Zeev, et al., 2010). This self-talk can influence the nature of behavior both in the short-term and the long-term (G. A. Miller, Galanter, & Pribram, 1960). Self-talk, whether activated intentionally or unintentionally, could influence behavior in a positive manner, as in the case of self-talk that is "opportunity thinking" or "self-reinforcing" (Hamilton, Scott, & MacDougall, 2007; Neck & Manz, 1992; Shi, Brinthaupt, & McCree, 2015), or in a negative manner, as in the case of self-talk that is "self-critical" or "obstacle thinking" (Neck & Manz, 1992; Shi et al., 2015). Below, we will return to the subject of self-talk and its effects on the conscious field and future behavior.

Another way in which prospective action-effects enter consciousness depends on the activation of *determining tendencies* (Ach, 1905/1951), which today are referred to as *action sets.* These action sets are prospective in nature, in the form, *when perceiving X in the future, then do Y*. For example, "when I see a mailbox, I must deposit the letter that I am carrying in my pocket." Experimental research reveals such task sets are often held in mind through the mechanism of subvocalization (Miyake, Emerson, Padilla, & Ahn, 2004), which is consistent with the view that subvocalization is used often for the regulation of action and thought (Luria, 1961; Sokolov, 1972). Often, once these sets are activated, then set-related stimuli trigger in consciousness the relevant prospective action-effects (e.g., depositing the letter), whether or not these stimuli influence behavior. Ach (1905/1951) speaks of the example in which, after activating the action set to "add things," the perception of the numbers three and five triggers the cognition, "eight," unintentionally and regardless of whether one utters the word aloud. The acquisition of such stimulus-response links through, for example, mere verbal instruction, often involving only one trial and without any training, has been characterized as something akin to the acquisition of a 'prepared reflex' or 'psychic reflex' (Ach, 1905/1951; Cohen-Kdoshay & Meiran, 2009; Exner, 1879; Gollwitzer, 1999; Hommel, 2000; Woodworth, 1939). (See relevant research on *implementation intentions* in Gollwitzer, 1999.)

Thus, action sets can bring into consciousness representations (prospective action-effects) that would not have become conscious otherwise. It is important to appreciate that an action set influences the future, not only by influencing which representations become conscious, but also by suppressing the behavioral expression of prospective action-effects that are irrelevant to that set. We can refer to this as the "keep your eyes on the prize" phenomenon. For example, when searching for a mailbox, one might, because of the sustained activation of this set, then not express the prospective action-effects triggered by the sight of an ice cream cone. In short, action sets have two long term consequences. First, they make one conscious of prospective action-effects that one would not have been conscious of otherwise, and, second, they can suppress, over a long period of time, the expression of set-irrelevant prospective action-effects. (When prospective memory is not intact, such shielding may fail; McDaniel & Einstein, 2007.) Both of these intriguing phenomena involving the induction of action sets have been investigated with a new experimental paradigm, the Reflexive Imagery Task (RIT; Allen et al., 2013), our next topic of discussion.

Prospective Cognitions in the Reflexive Imagery Task

The phenomena discussed above (including ideomotor mechanisms, encapsulation, subvocalization, action sets, conflict between prospective action-effects, action options, and the perceptual nature of prospective action-effects) have been investigated in an experimental and tractable manner with the RIT. In the task, which is based on the experimental approaches of Ach (1905/1951); Stroop (1935); Wegner (1989), and Gollwitzer (1999), prospective action-effects enter consciousness as a function of external control (i.e., instructed action sets and external stimuli). The paradigm reveals several insights regarding the nature of prospective cognition, including that, through the activation of action sets, prospective action-effects can enter consciousness in a manner that is reliable and insuppressible, resembling in some ways the functioning of a reflex. Although current variants of the RIT concern actions that unfold in the near future, because of the principle of atemporality, some of the mechanisms gleaned from the paradigm illuminate that which transpires during the simulation of actions in the distant future, as fleshed out below.

In the basic version of the RIT, subjects are presented with a visual stimulus (e.g., a line drawing; Figure 1) and instructed to not think of the name of the stimulus. We will present the reader with a demonstration of the most basic RIT effect. Momentarily, you will be presented with an object enclosed within parentheses. Your task is to not subvocalize the name of the object. Here is the object (▲). Did you experience the effect? If so, you have experienced what the vast majority of subjects experience in the RIT.[9] Subjects fail to suppress such subvocalizations on the majority of the trials (see Table 1). (Unlike in our demonstration, during a trial in the basic RIT [Allen et al., 2013], the visual object appeared for 4 s, during which time participants indicated by button press whether they subvocalized the object name.) When the effect arises, it does so only moments (~2 s) after the stimulus appears (see Table 1). (In many variants of the RIT, after each trial, participants input by keyboard the orthograph corresponding to the subvocalization they experienced.)

The RIT effect requires the sophisticated process of object naming, in which only one of tens of thousands of phonological representations is selected for production in response to a visual stimulus (e.g., the object CAT yields /k/, /œ/, and /t/; Levelt, 1989). In a more complex version of the task (Merrick, Farnia, Jantz, Gazzaley, & Morsella, 2015), participants were instructed to (a) not subvocalize the name of the visual stimulus, and (b) not subvocalize the number of letters in the object name. On a significant proportion of trials (.30 [SE = .04]), participants reported experiencing both kinds of imagery. Importantly, each thought arose from distinct, high-level processes (i.e., that of object naming vs. object counting). This variant of the RIT is important because it provides the first demonstration of the external control of the stream of consciousness: In this study, a sequence of two involuntary conscious thoughts, with one thought following the other, was elicited by an experimental manipulation involving external control.

The RIT Effect as a Prospective Action-Effect

Both the action set in the RIT (e.g., to not subvocalize the name of the object when it appears) and the involuntary subvocalization—which, in ideomotor terms, can be construed as a prospective action-effect—depend on anticipatory, forward-

[9] Regarding the accuracy of participants' reports, evidence from neuroimaging studies corroborates that, in paradigms in which participants must report about the occurrence of conscious contents, it is unlikely that participants are confabulating about these mental events (Mason et al., 2007; McVay & Kane, 2010; Mitchell et al., 2007; Wyland, Kelley, Macrae, Gordon, & Heatherton, 2003). Consistent with these findings, casual observation of the behavior of participants during each trial reveals that, upon experiencing the RIT effect, participants are very surprised by their inability to thwart the unintentional subvocalizations.

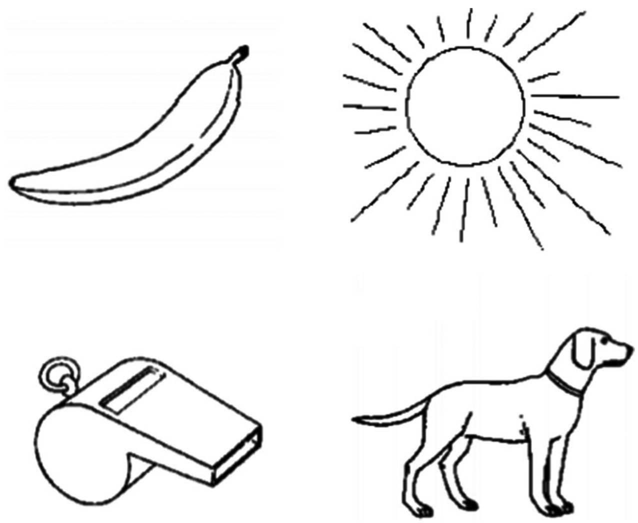

Figure 1. Sample visual stimuli (not drawn to scale).

looking processes. Although not influencing overt behavior, the subvocalization in the RIT can, as a prearticulatory output, be construed as an action option for to-be-produced behavior. The speech monitor (Levelt, 1989) detects the activation of the phonological form composing the subvocalization, and then, for some reason (e.g., the incompatible action set to *not* name the object), the lexical representation is *not* selected for production. Thus, the subvocalization exists only as a prearticulatory output that, as a fleeting action option, was experienced subjectively but did not influence overt behavior. Again, this prospective action-effect is isomorphic to what would be observed if the action were produced overtly.

The findings from the RIT complement the aforementioned theoretical approaches (e.g., Krisst et al., 2015; Morsella et al., 2015; Merker, 2013) in which the conscious field provides action options for subsequent behavior, as in our examples of "goo goo ga ga" and the funny phrase. As explained by the principle of encapsulation, the mechanisms generating these prospective action-effects "do not know," in a sense, whether the representations they introduce into the conscious field are relevant to ongoing action or to the other contents composing the field (Morsella et al., 2015). Figuratively speaking, the representations of prospective action-effects do not know whether, in the current context, they are desirable or not.

Important for the study of prospective cognition, the RIT sheds light on why not all of prospective action-effects lead to overt action and why many are experienced only as fleeting action options (including the urges to act one way or another): It is because potential courses of action may not be selected for production. In ideomotor theory, this happens when one prospective action-effect happens to be incompatible with another prospective action-effect. In the RIT, the subvocalization effect fails to elicit the overt naming because the representations happen to be incompatible with the action set (prospective in nature and held in memory) to not utter the object name aloud when presented with the stimulus.[10] It is worth reiterating that, in this situation, prospective action-effects are tokens of action selection that require no homunculus for their selection: Prospective action-effects fail to influence overt action only because they are suppressed by the activation of incompatible prospective action-effects (e.g., those associated with long-term goals; Lewin, 1935). Thus, under normal operations, for every potential action-effect that is not expressed, there must be some incompatible prospective action-effect. In this framework, there is no such thing as the action option of "doing nothing," a colloquial and unscientific expression (see similar conclusion in Skinner, 1953). (Today, there is substantial research on the neural correlates of nonaction [e.g., when voluntarily omitting a response to a stimulus; see review in Brass & Kühn, 2010]. Importantly, the findings from this research support ideomotor theory [Kühn & Brass, 2010].) For example, when mailing a letter and searching for a mailbox, the goal of seeking the mailbox suppresses the influence on behavior of the prospective action-effects that happen to be triggered by incidental environmental stimuli (Gazzaley, Cooney, Rissman, & D'Esposito, 2005). Because most human behavior is goal-directed (Lewin, 1935), behavior is usually shielded from the influence of transient, environmentally triggered prospective action-effects, as in our "keep your eyes on the prize" example.

As mentioned above, consciousness is about a stage of processing reflecting action options and not reflecting the representations, should they exist, that correspond to the outcome of the competition between these options (i.e., between prospective action-effects; Morsella, 2005). In line with this theorizing, in one experiment (Allen et al., 2013), participants performed one of two kinds of actions: to count or to color-name in response to an array of stimuli (e.g., shapes). When selecting one of the two action sets, participants nonetheless often experienced conscious imagery from the unselected action set. In other words, when participants performed action *X*, they often experienced conscious imagery about option *Y*, a potential but unselected action. Similar effects were found in a separate condition, in which the experimenter selected the action set for the participant. (It is important to note that, unlike in the basic RIT, the stimuli used in this study were not the kinds of line drawings that, in elementary school, are associated with naming responses.) This experiment provides further evidence that prospective action-effects are often experienced only as fleeting action options (including urges to act one way or another) that happen to conflict with other, prepotent prospective action-effects. Investigators have begun to examine the behavioral consequences of such unselected action options (Filevich & Haggard, 2013). With this in mind, it is interesting to consider that, in some variants of the RIT, participants type in, after each trial, the name that came to mind after being presented with the stimulus. In this case, what was an unselected action option during the trial does in fact influence behavior, but only after the conclusion of the trial.

[10] Participants can easily suppress overt object-naming responses in the RIT, although they experience both the subvocalization and, at times, even the urge to name the object aloud (Allen et al., 2013). (In some neurological conditions [e.g., ambient echolalia], such suppression is not as facile.)

Table 1
By-Subject Mean Values as a Function of Study

Study	Sample size	No. of trials	Proportion of trials with subvocalizations	Latency (ms)	Proportion of RIT effects on first trial
Allen et al. (2013)	15	20	.86 (.24) *Range*: .15–1.0	1,451.27 (611.42) *SE* = 157.87 *Minimum*: 328.80	.67 (.47)
Cho et al. (2014)	76	20	.87 (.19) *Range*: .05–1.0	2,323.91 (1,183.01) *SE* = 135.70 *Minimum*: 924.00	.95 (.22)
Merrick et al. (2015)	36	52	.73 (.23) *Range*: .15–.98	1,745.97 (620.86) *SE* = 103.48 *Minimum*: 445.63	.81 (.40)
Bhangal et al. (2015)	33	80	.70 (.28) *Range*: .04–1.0	1,775.67 (546.56) *SE* = 95.14 *Minimum*: 829.01	.76 (.43)

Note. *SD*s presented in parentheses.

Component Processes of the Prospective Action-Effect in the Reflexive Imagery Task

The activation of prospective action-effects in the RIT appears to rely on several component processes (Allen et al., 2013). For instance, as discussed in Allen et al. (2013), the effect depends on the appropriate induction of a prospective, action set (e.g., to not subvocalize the name of a soon-to-appear object). The action set held in mind, from the beginning of the trial until the onset of the visual object, can be construed as a kind of *imageless thought*, because it influences behavioral dispositions without being maintained explicitly in consciousness (cf., Woodworth, 1915; see recent, relevant research in Scullin, McDaniel, & Einstein, 2010). (Imageless thought was first investigated by theorists of the Würzburg School of Psychology; Schultz & Schultz, 1996.) The final process occurs when the onset of the visual object begins the stages of processing that lead to the prospective action-effect (e.g., the subvocalization).

It is important to note that, without the activation of the relevant action set, it is unlikely that participants would experience the phonological representations of the names of the objects that are perceived visually. With the foregoing in mind, it is important to point out that, in the initial research report using the RIT (Allen et al., 2013), there was an *Incidental Naming* condition in which participants were not provided with the 'do not think' instruction that leads to *ironic* effects (discussed below; Wegner, 1994). Instead, the condition involved no explicit instructions regarding naming or not naming. The condition served to assess, to at least some extent, participants' spontaneous subvocalization rates in response to the stimuli when having no obvious action set toward the stimuli. It is likely, of course, that simply mentioning to participants the possibility of naming will increase the likelihood of subvocalization, which is a limitation of this condition. Nevertheless, for this condition, subvocalizations of object names still arose on 99% of the trials (range = 80% to 100%). When examining how often the effect occurred on the very first trial, the proportion was comparable (31 [97%] of 32 first trials). Such subvocalizations toward the visual objects arose even when participants, before being presented with a visual object, performed a block of trials of a task having another kind of action set (e.g., the Stroop task; Merrick, Cho, & Morsella, 2014). The data from the *Incidental Naming* condition are consistent with the idea that the RIT instructions are not introducing a task set into a cognitive apparatus that is currently "set free." Rather, the subject, upon entering the laboratory, already possesses a plethora of activated task sets, many of which are primed by the stimuli (e.g., the computer and keyboard) composing the scene. The experimenter, when mentioning the RIT instruction, is in effect prioritizing some action sets over others. (In Allen et al. [2013], there was also an *Intentional Naming* condition, in which participants were instructed to subvocalize the name of the object, leading to subvocalizations on 99% of the trials.)

Based on the evidence described above, one might conclude that, once the naming set (a prospective, determining tendency) is activated through one means or another, the RIT effect is likely to arise. From the standpoint of Morsella et al. (2015), the RIT effect arises when the field is refreshed as a whole after the set has been activated by the instructions. Methodologically, the instruction to not perform a certain mental operation is just a useful way of activating the relevant action set. (The method is useful because, when the effect arises unintentionally, there is less likelihood that the conscious thoughts stem from artifacts from experimental demand, strategic processing, or social desirability; Allen et al., 2013.) It may be that many circuits in the brain do not, in a sense, "understand" syntactic negation. Thus, an instruction such as "NO ICE CREAM" might lead to the activations and dispositions (e.g., appetitive propensities) associated with the prompt "ICE CREAM" (Draine & Greenwald, 1996; Harris, Pierce, & Bargh, 2013; Olsson & Phelps, 2004).

One could argue that prospective action-effects can be activated only by cued-memory retrieval and not by more complex processes (e.g., symbol manipulation). However, this is inconsistent with the observation that RIT effects still arose in a variant involving a word-manipulation task similar to Pig Latin (e.g., "CAR" becomes "AR-CAY"). In this variant of the RIT (Cho, Zarolia, Velasquez, & Morsella, 2015), participants were instructed to not transform stimulus words according to the rule, but involuntary transformation still arose on more than 40% of the trials. This effect is striking because the involuntary transformation requires complex symbol manipulations and processes associated with frontal cortex (B. L. Miller & Cummings, 2007). In short, the more that is learned about the generation of high-level conscious contents in the RIT, the more it appears that this generative process resembles that of lower-level processes.

It remains unclear how much of the RIT effect stems from the mere activation of action sets (which can be activated incidentally in several ways, including by instructions to *not* perform a certain action), and how much of the effect stems from more complex phenomena, such as that proposed by Wegner (1994). Wegner (1994) proposes that the kind of involuntary, 'ironic' effect in the RIT arises from an interaction between two distinct processes. One process is an *operating* process, which is associated with the conscious intention to maintain a particular mental state. This process actively scans mental contents (e.g., thoughts, sensations) that can help maintain the desired mental state (e.g., to be calm). This process tends to be effortful, capacity-limited, and consciously mediated (Wegner, 1994).[11] The other mechanism is an 'ironic' *monitoring* process that automatically scans activated mental contents to detect contents signaling the failure to establish the desired mental state. When the monitor detects contents that signify failed control of the operating mechanism, it increases the likelihood that the particular content will enter consciousness, so that the operating mechanism then processes the content and changes its own operations accordingly. Pertinent to the RIT, the ironic monitor mechanism is usually unconscious, autonomous, and requires little mental effort. (The neural correlates of this monitoring process have been investigated.[12]) In most cases of cognitive control, the two mechanisms work together harmoniously. However, harmony fails when the goal in mental control is to not activate a particular mental content (e.g., content *X*), because (a) the operating process can bring only goal-related contents into consciousness and cannot actively exclude contents, and (b) the ironic monitor will reflexively bring into consciousness mental contents (e.g., content *X*) that are incongruent with the goal. Together, the interaction of the two mechanisms—intentional *operating* process and the ironic *monitoring* process—will lead to the automatic activation of content *X* in consciousness. (For reviews of ironic processing and thought suppression, see Rassin, 2005; Wegner, 1989; for the neural correlates of ironic processing, see Footnotes 11 and 12.)

What the RIT Reveals About the Encapsulation of Prospective Action-Effects

If many prospective action-effects are encapsulated and involuntary, then prospective action-effects should be experienced as automatic and "immediate." What does the RIT reveal about this? The RIT provides evidence that prospective action-effects can arise automatically in consciousness. In one version of the RIT, participants reported on the majority of trials (proportion = .71, SE = .03) that the subvocalization effect felt "immediate" (Bhangal, Merrick, & Morsella, 2015). Hence, it seems unlikely that participants are thinking of the object name incidentally, through the following kind of reasoning process. "You told me to not think of the name of the object. The object name is *X*. Therefore, I should not think of *X*." That the effect is experienced as immediate is consistent also with Wegner's (1994) aforementioned model of ironic processing.

The view that the activation of prospective action-effects is automatic is further supported by the observation that, on some RIT trials, the effect arises too quickly to be caused by strategic processing (Allen et al., 2013; Cho, Godwin, Geisler, & Morsella, 2014). Moreover, the effect still arose under conditions of cognitive load, in which it is difficult for participants to implement strategic processing (Cho et al., 2014). Last, the effect is unlikely to be attributable to strategic processing or demand characteristics because the subvocalizations are influenced systematically by factors such as word frequency (Bhangal et al., 2015). Such an artifact of experimental demand would require for participants to know how word frequency should influence responses in an experiment. One could argue that, if the RIT effect is similar to a reflex, which is encapsulated, then the effect should habituate as reflexes do. Indeed, this appears to be the case: Repeated presentation of the same RIT stimulus across a series of trials (n = 10) will habituate the RIT effect for that specific stimulus, such that the effect is more likely in the first five trials than in the subsequent trials (Bhangal, Allen, Geisler, & Morsella, 2016).

If the prospective action-effect triggered in the RIT is encapsulated, then it should also be difficult to suppress voluntarily. Participants do try different strategies to suppress the unintended subvocalizations.[13] In one study (Cho et al., 2014), subjects were instructed to reiteratively subvocalize a speech sound ("da, da, da") throughout the entire RIT trial. Presumably, this intentional subvocalization targets the 'phonological store' that is responsible for the involuntary subvocalizations of the RIT effect (see Footnote 7). Nevertheless, the RIT effect still arose on more than 80% of the trials. One could propose that subvocalizations occurred only because of the moments of silence between the intended speech sounds, but this is inconsistent with the observation that

[11] Neuroimaging studies suggest that the action set to perform a simple action (such as to *not* subvocalize an object name or to follow another simple rule of behavior) involves prefrontal cortex (B. L. Miller & Cummings, 2007; E. K. Miller, 2000; Munakata et al., 2011). More specifically, in ironic processing, the effortful, *operating* process involves the dorsolateral prefrontal cortex (Anderson et al., 2004; Mitchell, Baxter, & Gaffan, 2007).

[12] The detection of involuntary cognitions, such as those of the RIT effect, is associated with activities in the anterior cingulate cortex (Anderson et al., 2004; Mitchell et al., 2007; Wyland et al., 2003). (For an electroencephalography study on thought suppression, see Giuliano & Wicha, 2010.) This region, located on the medial surface of the frontal lobe and interconnected with many motor areas, has been associated with cognitive control (Gazzaley & Nobre, 2012), including the detection of error-prone processing (Brown & Braver, 2005), cognitive conflict (Cohen, Dunbar, & McClelland, 1990), and inefficient processing (Botvinick, 2007). Inefficient processing includes both error-prone and conflict-related processes. (See Levy & Anderson, 2002, 2008, 2012, for discussions of the role of the anterior cingulate cortex, lateral prefrontal cortex, and hippocampus in the suppression, not of involuntary subvocalizations, but of undesired memory retrieval.)

[13] For example, they may be using various strategies, including self-distraction (Wegner, Schneider, Carter, & White, 1987; see evidence of positive effects from self-distraction in Hertel & Calcaterra, 2005). Indeed, in the initial study (Allen et al., 2013), the funneled debriefing data revealed that some participants attempted to suppress the subvocalizations by subvocalizing something else (e.g., a melody). When referring to an experimental finding by Hertel and Calcaterra (2005), Bulevich, Roediger, Balota, and Butler (2006) state that "suppression instructions to not think of an unwanted response may succeed if subjects are given the strategy (or themselves hit upon the strategy) of always thinking of some other item when they are trying to suppress an unwanted response" (p. 1575). Occupying the mind with verbal information may indeed delay entry of the subvocalization.

comparable results arose even when participants subvocalized a continuous, unbroken hum ("daaa. . . .") throughout the entire trial. This finding reveals that the effect, because of the encapsulated mechanisms giving rise to it, cannot be 'turned off' voluntarily. Interestingly, in the study, it appeared that the intentional, continuous hum and the object name coexisted simultaneously in the conscious field, an intriguing datum which requires further investigation.[14]

What the RIT Reveals About Mental Simulation and Cognitive Control

To influence in a roundabout manner the encapsulated processes associated with incentive/motivational states, humans often use *indirect cognitive control* (e.g., making oneself hungry by thinking of certain foods; Morsella, Lanska, Berger, & Gazzaley, 2009; Morsella, Larson, & Bargh, 2010). This form of control can be contrasted with *direct cognitive control* (e.g., when one wills to snap one's finger or think of a tree). Indirect cognitive control is used in practices such as "method acting," in which, through mental imagery, actors intentionally induce the emotional states that are necessary for a scene. It could also involve self-talk, as when athletes in a competition activate aggressive tendencies in themselves by saying certain things to themselves. In mental simulation, self-talk could be used to activate the incentive/motivational states that are necessary to render simulacra more accurate and predictive. For example, self-talk may, in a simulation, activate conscious contents (e.g., content *X*) that are not triggered by the present external environment. To return to our 'mopped floor' example, to simulate future action selection in such a scenario, one might make oneself more fearful through the technique of self-talk (e.g., by saying scary things to oneself).

What does the RIT reveal about indirect cognitive control? Interestingly, it seems that RIT effects are more likely to arise for processes that would normally be amenable to direct cognitive control than for processes arising only from indirect cognitive control. For instance, one can choose to add numbers, subtract numbers, or even play the game of Pig Latin; however, one cannot, by sheer will and without some difficulty, make oneself ecstatic or frightened. Hence, it seems that subjects in an experiment would find it easier to follow the instruction "Do not make yourself feel ecstatic [or some other emotional/incentive state]" than the instruction "Do not think of the name of this object" (Cho et al., 2015). Interestingly, it might be the case that those processes for which one normally has the most control (i.e., direct cognitive control) are the very processes that are most susceptible to ironic processing in the RIT (Cho et al., 2015).

It is worth adding that, according to Morsella et al. (2015), the conscious field contains various kinds of contents (e.g., percepts and action-related urges), all of which serve to constrain the process of action selection (specifically, action selection in the skeletal muscle output system). (Prospective action-effects are just one kind of these conscious contents.) From this standpoint, this constraining process is essential for voluntary action to be adaptive. Interestingly, as hypothesized in Morsella et al. (2015) and illuminated by the RIT effect, that which renders these representations prospective is not the conscious field itself, but rather the systems that, behind the scenes, generate these contents. According to Morsella et al. (2015), the conscious field is passive and only "presents," in a sense, conscious contents (many of which are generated unconsciously) to another group of unconscious processes—the *response systems* of the skeletal muscle output system. Most content generation occurs unconsciously, as in the case of Helmholtz's unconscious inferences.

From this perspective, and as is evident in the RIT effect, prospection is automatically (and unconsciously) "built into" the activities of the content generators that furnish the field with its various objects, urges, and representations of action-effects. For example, in the RIT, one sees an object and then experiences the prearticulatory outputs (the subvocalization) of the object name. In another scenario, one could hear a fragment of a famous lyric and then experience the conscious recollection of the subsequent part of that phrase (e.g., "Oh, say, can you . . ."). Similarly, when one hears three notes of a well-known melody, one automatically thinks of the fourth note. The content generation is forward-looking. Seldom does it work the other way. For example, never does one hear the opening notes to a song from a well-known album and then spontaneously recall the last notes of a preceding song. With this in mind, one could hypothesize that RIT effects are more likely to arise with instructions such as "Do not think of the following note in a familiar song" than with instructions such as "Do not think of the preceding note in a familiar song." Similarly, RIT effects might be more likely to arise with instructions to the effect of "Do not think of the following word in a familiar phrase" than to the effect of "Do not think of the preceding word in a familiar phrase."

Conclusions About Prospection and Action

> 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, p. 771)

Voluntary action is just one of many forms of behavior exhibited by the human organism. It is a peculiar form of action, one that is intimately related to prospection-based mechanisms (e.g., ideomotor processing and other forms of inverse modeling). As acknowledged in James's quote, before performing a voluntary action, one's conscious mind is occupied with *what that action is to be*, or, more technically, with *prospective action-effects*. In the RIT, prospective action-effects (e.g., subvocalizations or counting) are isomorphic to what would be observed if the actions were produced overtly. For example, in the basic version of the RIT task, the subvocalized response to the picture of a house is isomorphic in some way, not with the input stimulus (a line drawing), but to what would be experienced in the future if one uttered the phonological form /haus/. In ideomotor theory, prospective action-effects could be construed as 'action options' that, residing in consciousness (James, 1890), may or may not influence upcoming

[14] If ever there is successful suppression of the RIT effect, we remain agnostic regarding whether such suppression is consistent with 'inhibition' accounts of cognitive control (cf., Aron, 2007; Levy & Wagner, 2011) or with other accounts concerning the control of action and cognition. Regarding the latter, ideomotor approaches would interpret successful suppression as resulting, not from direct inhibition of the undesired action plan, but from the sustained activation of an incompatible action plan (Hommel, 2009). (See relevant models of inhibition in Logan et al., 2015, and in Munakata et al., 2011.) Future investigations could further mine the phenomenon of the RIT and determine whether it is consistent with an inhibition account of control or with other contemporary accounts.

behavior, depending on the nature of, not the whims of a homunculus, but rather the nature of the other prospective action-effects that happen to be activated at that time (Morsella et al., 2015). If a prospective action-effect is activated and does not happen to be at odds with any other prospective action-effect, then it must influence behavior automatically.

As revealed by the RIT, action sets are prospective in more ways than one. First, they make one conscious of prospective action-effects that one would not have been conscious of otherwise; second, they can suppress, over a long period of time, the expression of set-irrelevant prospective action-effects (e.g., vocalization of the object name). Consistent with the principle of atemporality and with frameworks in which the conscious mind is viewed as a passive system (Morsella et al., 2015), the RIT reveals the inflexible nature of the generation of prospective action-effects: Given action set *X* and stimulus *Y*, one will experience prospective action-effect *Z*, which is unexpressed at a given moment only because of the activation of an incompatible action set.

We also discussed how prospection is built into the generation of conscious contents. This notion, when combined with the principle of encapsulation, reveals a peculiar cognitive architecture in which the nature of the contents of the conscious field—that which encompasses the totality of our existence as sentient beings, and, importantly, which wholly and exclusively determines the nature of voluntary action selection (Morsella et al., 2015)—is biased, like a loaded coin, toward one direction in time, even when that bias goes against one's current intentions (e.g., to "focus on the present"; Morsella et al., 2010). When this line of reasoning is combined with the principle of atemporality and with the idea that a particular collection of prospective action-effects will always lead to the same outcome in action selection, then one realizes that both the conscious field and voluntary action selection (as explained by ideomotor theory) are, for good or for bad, built on an uneven foundation, one that does not necessarily take into account all of the information surrounding stimulus *X* (e.g., a note in a song) but rather is myopically concerned about information regarding what will happen next (e.g., the next, but not previous, note in a song). (Robotic systems that, by use of artificial intelligence, strive to emulate human action control should perhaps incorporate this future-looking bias into their cognitive architectures.)

The experimental findings reviewed above reveal that, once a certain action set is activated, then set-related stimuli must trigger in consciousness the relevant prospective action-effects, whether or not these stimuli influence behavior. In this way, a long-term goal influences which prospective action-effects are experienced consciously. For example, when training for a marathon, the sight of a staircase might trigger the idea of using it for the purpose of conditioning the body. Similarly, when preparing for a musical performance that will occur in one month's time, the sound of a high-pitched door bell might remind one of the notes that, in a to-be-performed song, follow that kind of high-pitched sound.

The RIT effect allows one to appreciate that the unpredictability in everyday life of the activation of prospective action-effects reflects, not so much the workings of an indeterminate and *un*-mechanistic system, but, more parsimoniously, the vagaries of quotidian stimulus environments. According to ideomotor theory, overt naming in the RIT fails to arise only because the prospective action-effect of the subvocalization conflicts with the action set of not naming objects aloud. Under normal circumstances—and in the absence of certain debilitating neurological conditions—the system yields adaptive behavior, which in the RIT consists of the subject sitting in front of the visual stimulus, quietly.

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