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The Essence of Conscious Conflict: Subjective Effects of Sustaining Incompatible Intentions

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Conflict constitutes one of the fundamental "tuggings and pullings" of the human experience. Yet, the link between the various kinds of conflict in the nervous system and subjective experience remains unexplained. The authors tested a hypothesis that predicts why both the "hot" conflicts involving self-control and motivation and the "cooler" response conflicts of the laboratory lead to changes in subjective experience. From this standpoint, these changes arise automatically from the activation of incompatible skeletomotor intentions, because the primary function of consciousness is to integrate such intentions for adaptive skeletal muscle output. Accordingly, the authors demonstrated for the first time that merely sustaining incompatible intentions (to move right *and* left) in a motionless state produces stronger subjective effects than sustaining compatible intentions. The results held equally strongly for two different effector systems involving skeletal muscle: arm movements and finger movements. In contrast, no such effects were found with conflict in a smooth muscle effector system. Together, these findings illuminate aspects of the nature of subjective experience and the role of incompatible intentions in affect and failures of self-control.

Keywords: conflict, cognitive conflict, subjective experience, consciousness, self-control

Conflict in the nervous system can color subjective experience in various ways. Its subjective effects can be innocuous and fleeting, as in the *response conflict* experienced during a laboratory response-interference task (e.g., Bush, Shin, Holmes, Rosen, & Vogt, 2003; Eriksen & Schultz, 1979; Husain, Parton, Hodgson, Mort, & Rees, 2003; Morsella et al., in press; Stroop, 1935), or they can be aversive, debilitating, and pronounced, as in the more "hot" (Metcalfe & Mischel, 1999) conflicts involving motivation and self-control (e.g., approach-approach conflicts; Livnat & Pippenger, 2006; Miller, 1959). Subjectively, there is certainly *something it is like* (the defining feature of subjective experience[1]) to want to both eat *and* not eat a marshmallow while delaying gratification (Mischel & Metzner, 1967), to exercise *and* cease exercising when exerting self-control at the gym, or to desire to be two places at once in a classic approach-approach conflict (Lewin, 1935), just as there is something it is like to produce a response that conflicts with a more prepotent, practiced response, as in a response interference task. What is it about these situations that affects subjective experience?

Despite its central role in constituting the fundamental "tuggings and pullings" and "ups and downs" of the human emotional experience, the relationship between conflict and subjective experience remains *terra incognita* from a scientific standpoint.[2] For example, theories of cognitive control have illuminated the influence that response conflict has on the activity of certain brain regions and behavior (Botvinick, Braver, Carter, Barch, & Cohen, 2001; Brown & Braver, 2005; Curtis & D'Esposito, 2009; van Veen & Carter, 2006), but for the most part they have been silent regarding the effects that it has on subjective experience (see

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[1] Subjective experience (also "consciousness," "sentience," or "awareness") is difficult to define. It is proposed to exist in an organism if there is *something it is like* to be that organism (Nagel, 1974)—something it is like, for example, to be human and experience pain or yellow afterimages.

[2] This may be because the basic relationship between *any* nervous process and subjective experience remains profoundly mysterious (Crick & Koch, 2003) and because these ineffable phenomena are not amenable to standard laboratory methods (e.g., neuroimaging and response time analyses).

exceptions in Mayr, 2004; Mayr, Awh, & Laurey, 2003; Mulert, Menzinger, Leicht, Pogarell, & Hegerl, 2005; Rosen, McGuire, & Botvinick, 2007).[3]

Take, for instance, what has and has not been scrutinized in the most thoroughly investigated paradigm involving response conflict: the Stroop task (Stroop, 1935). In this task, participants name the colors in which stimulus words are written. When the word and color are incongruous (e.g., RED presented in blue), response conflict leads to increased error rates and response times (RTs; Cohen, Dunbar, & McClelland, 1990). When they are congruous (e.g., RED presented in red), there is little or no interference (see review in MacLeod & MacDonald, 2000). It is obvious to the participant and experimenter alike that the task is also accompanied by notable changes in subjective experience, rendering it qualitatively different from that of normal color-naming. Yet, less has been documented about these subjective phenomena than about the cognitive, behavioral, and neural features of the task.

In accord with recent views (van Veen & Carter, 2006), we believe that unraveling the nature of the subjective effects associated with the response conflict of such a task is essential for understanding the dynamics underlying the hot action conflicts of everyday life. To this end, we present evidence in support of a new hypothesis that predicts in a parsimonious fashion why hot conflicts and the "cooler" response conflicts invoked in the laboratory lead to changes in subjective experience.

Conscious and Unconscious Conflicts

Many conflicts in the nervous system are opaque to introspection and can be resolved unconsciously, while some are experienced subjectively (see review in Morsella, 2005). *Unconscious conflicts* are featured in reflexes, actions of the viscera, and a plethora of intersensory conflicts, such as ventriloquism and McGurk effects (Logothetis & Schall, 1989; McGurk & MacDonald, 1976; Vroomen & de Gelder, 2003). For example, the McGurk effect involves a conflict between visual and auditory information: an observer views a speaker mouthing "ba" while presented with the sound "ga." Surprisingly, the observer is unaware of conflict, perceiving only "da." *Conscious conflicts* are experienced when one refrains from dropping a hot dish, holds one's breath, or suppresses eating or elimination behaviors. If trapped underwater, for instance, one feels the urge to breathe (for not breathing leads to death) and the urge to refrain from doing so (for inhaling leads to drowning).

To explain this entire pattern of observations, Morsella (2005) proposed that people become conscious only of conflicts involving competition for control of the skeletal muscle system (hereafter, "skeletomotor" system). This hypothesis is from a theory (Morsella, 2005) in which the primary function of consciousness is to integrate potentially conflicting skeletomotor intentions. Conflicting intentions usually arise from high-level, multimodal systems that are defined via "concerns" (e.g., certain bodily needs). These systems vie to control the same skeletomotor "steering wheel," and it is only through consciousness that they can "cross-talk" and influence action collectively. This idea is captured by the principle of *Parallel Responses into Skeletal Muscle* (PRISM). For example, skeletomotor plans are involved in the expression (or suppression) of inhaling, blinking, pain withdrawal, micturating, and defecating, all of which can be mediated consciously. Conversely, no skeletomotor plans are directly involved in the pupillary light reflex, peristalsis, or bronchial dilation, all of which involve smooth muscle and are consciously impenetrable. Accordingly, in a process such as digestion, one is conscious of only those phases requiring coordination with skeletomotor plans (e.g., chewing, micturating) and none of those that do not (e.g., peristalsis). One does not need consciousness for *unintegrated actions*, such as inhaling reflexively or automatically withdrawing one's hand from a painful stimulus, but one does need it for *integrated action* (e.g., holding one's breath; Morsella & Bargh, in press).

This framework also explains why skeletal muscles are "voluntary" muscles (see definition of voluntary in Passingham, 1995): skeletomotor actions are at times "consciously mediated" because they are directed by systems that, when in conflict, require consciousness to yield adaptive action. The framework's emphasis on the relationship between consciousness and action echoes James's (1890) adage that *thinking is for doing*, a view for which there is growing evidence from research on "embodied cognition" (Cacioppo & Berntson, 1994; Glenberg, 1997; see review in Morsella, 2009). Indeed, theorists propose that the function of explicit, conscious memory is to simulate future, potential actions (Schacter & Addis, 2007) and that even states like cognitive dissonance are intimately related to action (Harmon-Jones & Harmon-Jones, 2002). Clearly, extensive research is needed to validate such a framework.

Hypothesis

For present purposes, we will focus only on a key hypothesis from this approach that may illuminate the essence of conscious conflict—that *the mere activation of incompatible skeletomotor intentions in-and-of-itself must trigger strong changes in subjective experience*, because the primary function of consciousness is to integrate such intentions for adaptive skeletomotor output. The hypothesis predicts in a parsimonious fashion why both response conflicts and hot action conflicts yield subjective effects. For the latter, there is a skeletomotor plan associated with each goal participating in the conflict, and the plans of one goal are incompatible with those of the other goal. In the delay of gratification, for example, the plan of eating is incompatible with that of *not* eating; while holding one's breath underwater, the plan of inhaling is incompatible with that of *not* inhaling. Similarly, in the Stroop task, incompatible intentions are manifest when word stimuli activate conflicting word-reading and color-naming plans (Cohen et al., 1990).

More generally, the hypothesis is consistent with the observation that conflicts occurring at perceptual levels of processing (e.g., intersensory conflicts as in the McGurk effect) do not perturb subjective experience as do conflicts occurring at response selection levels of processing (Morsella et al., in press), whether in interference tasks, approach-avoidance conflicts, or the delay of gratification. Figuratively, people tend not to experience perturbations in subjective experience while watching a ventriloquist or

[3] Oversight of the subjective effects of cognitive processes cannot be ascribed to the whole of experimental psychology, as these effects have been examined systematically in many subfields, including psychophysics (e.g., Stevens, 1956) and metacognition (e.g., Fernandez-Duque, Baird, & Posner, 2000; Johnson & Raye, 1981).

being subjected to the McGurk effect, but such is not the case while they perform the Stroop task or exert self-control (Baumeister & Vohs, 2004; Preston & Wegner, 2009).

Another example involves the Eriksen interference task (e.g., Eriksen & Schultz, 1979). In this task, participants are trained to press one button with one finger when presented with the letter "S" or "M" and to press another button with another finger when presented with the letter "P." After training, participants must respond to the stimulus presented in the center of an array (e.g., SSPSS, SSMSS, targets underscored) and to disregard flanking stimuli (the distracters). Greater interference is found when the distracters are associated with a response that is different from that of the target (*response interference*; e.g., SSPSS) than when they are different in appearance but associated with the same response (*stimulus interference*; e.g., SSMSS).

Regarding subjective experience, participants report more "urges to err" when visual distracters are associated with a response that is different from that of the target (*response interference*) than when distracters are different in appearance but associated with the same response (*stimulus interference*; Morsella et al., in press). One limitation of this approach is that the former may just be more difficult than stimulus interference, because it features both kinds of interference. It is interesting to note that in a neuroimaging study, van Veen, Cohen, Botvinick, Stenger, and Carter (2001) demonstrated that, though both response and stimulus interference are associated with differences in performance, only the former activates the anterior cingulate cortex, a brain region that is believed to be involved in both conflict detection and conscious processing (Botvinick et al., 2001; Brown & Braver, 2005; Crick, 1995; Mayr, 2004; Mayr et al., 2003). Regarding the subjective aspects of the Stroop task, when response interference is low or absent (as in the congruent condition), participants report low "perceptions of competition"; when interference is high (as in the incongruent condition), perceptions of competition tend to be high (Morsella et al., in press).

Along with the hot conflicts mentioned above, these laboratory findings suggest that, when a task or situation involves incompatible intentions, there are strong changes in consciousness. However, although suggestive, these data fall short of addressing our critical hypothesis, because, for both hot conflicts and laboratory-elicited response interference, the data stem from situations involving more than just the activation of incompatible intentions. For example, response interference tasks also include activation of a host of executive processes and the suppression of (often prepotent) action plans (e.g., Stroop and flanker tasks; Cohen et al., 1990; DeSoto, Fabiani, Geary, & Gratton, 2001; MacLeod & MacDonald, 2000); and hot conflicts usually include a combination of response suppression, need deprivation, and noxious stimulation, as explained below. In short, the subjective effects associated with the aforementioned scenarios and tasks could result from many factors other than the mere activation of incompatible skeletomotor intentions.

Processing Dynamics and Subjective Experience

The rationale of our approach is as follows. *If the activation of incompatible action plans is the key ingredient giving rise to the subjective effects that arise during response/action conflicts, then such activation in-and-of-itself should lead to subjective effects in other situations.* To test the hypothesis, it needs to be demonstrated that merely activating or sustaining incompatible intentions in-and-of-itself produces systematic changes in subjective experience. One challenge in isolating such an effect is that subjective experience is inherently multidimensional and can be influenced both by the nature of ongoing cognitive processing and by the resultant consequences of such processing (Gray, 2004). Thus, it is difficult to distinguish the "processing-based" subjective effects (*primary effects*) of these conflicts from their indirect subjective effects (*secondary effects*). When holding one's breath or delaying gratification, for example, one presumably experiences both the effects of sustaining incompatible intentions (a form of metacognition) as well as secondary effects, such as the subjective effects caused by the afference arising from the bodily consequences of breathlessness or food deprivation.

Regarding primary effects, substantial research has shown that certain kinds of cognitive processing engender affective states which then influence judgments and behavior: When processing is smooth and facile, as during the processing of visual stimuli that are familiar, prototypical, or easy to perceive (e.g., high figure-ground contrast), the processing tends to generate positive affect (cf., Jacoby, Kelley, & Dywan, 1989; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). As well, Higgins (2005) has shown that the actual manner in which one pursues a goal can influence the valence toward things associated with that goal, independent of the nature of the goal and its pursuit. As mentioned above, the subjective dynamics associated with conflict have received substantially less attention (but see review on affect and cognitive control in Reis & Gray, 2009). Nevertheless, it has been documented that conflict-related changes in subjective experience are associated with failures in self-control, as in the case of relapse in drug addiction (Baker, Japuntich, Hogle, McCarthy, & Curtin, 2006; Baker, Piper, McCarthy, Majeskie, & Fiore, 2004).

To isolate the primary effects of activating incompatible intentions, one must consider that these effects may exist with little or no secondary effects under certain conditions, as when one wants to go to two places at once. A dramatic example of this is when a soccer goalie prepares to leap both left and right in the moments prior to a penalty kick. During this state, the goalie is sustaining incompatible action plans, at least to a certain extent. We propose that, as predicted (Morsella, 2005), the subjective experience associated with merely activating and sustaining such incompatible intentions (e.g., the preparedness to leap both right *and* left) differs systematically from that associated with coexpressible intentions (e.g., the preparedness to simultaneously leap right and, say, catch the ball).

To this end, we developed a paradigm in which participants were trained to introspect conflict-related aspects of cognition during an interference task and then were instructed to introspect the same "thing" while sustaining simple compatible and incompatible intentions, intentions analogous to those of our goalie example. We arrived at the idea of introspection training because piloting ($n = 6$) revealed that, without some form of training, different participants interpreted questions regarding their experience of sustaining intentions to mean different things. Subjective experience contains multiple dimensions that one can introspect on and report about; hence, training is essential in order for participants to have an unbiased way in which to identify the dimension of interest.

We focused only on the hypothesis that *sustaining incompatible skeletomotor intentions yields stronger changes in subjective experience than compatible or identical intentions.* We tested it under two assumptions: (a) that mentally holding motor intentions activates to some extent the motor plans used to behaviorally express those intentions, an assumption for which there is substantial support (e.g., Chambers & Mattingley, 2005; Curtis & D'Esposito, 2009; Rizzolatti, Riggio, Dascola, & Umiltá, 1987), and (b) that such activation of incompatible intentions occurs not just during intense conflicts that have secondary effects but during any conflict involving the activation (or sustaining) of incompatible plans, including those innocuous conflicts that lack secondary effects (e.g., the goalie's predicament). From this theoretical standpoint, a change in subjective experience (i.e., a conscious signal) is inflexibly triggered by the mere coactivation of incompatible plans, regardless of the source or nature of this coactivation (Morsella, 2005).

Overview of the Paradigm

Participants were trained to introspect about the dimension of interest by having them rate their urge-to-err during the Stroop task. During training, participants named the colors in which stimulus words were written. Following each response, participants were asked "How strong was the urge to make a mistake?" They rated the question on an 8-point scale, in which 1 signified *almost no urge* and 8 signified *extremely strong urge*. *Introspection training* consisted of 24 Stroop trials having eight congruent (e.g., RED written in red), eight incongruent (e.g., RED in blue), and eight control (e.g., HOUSE in green) stimuli in random order. The training was short and consisted of few trials, because we did not want participants to become habituated to the exercise and hence experience weakened urges. We assumed that, when measuring this urge, participants presumably introspect and report on the subjective experience associated with the conflict between the dominant word-naming and weaker color-naming responses (Cohen et al., 1990), though one cannot rule out that these judgments are influenced by arousal or a sense of effort from managing response conflict (see General Discussion). Based on theory (Morsella, 2005) and previous findings (Morsella et al., in press), we predicted that the greatest urges to err would be reported in the incongruent condition (in part because this condition invokes incompatible action plans) and that the weakest urges to err would be reported in the congruent condition (in part because this condition does not involve incompatible plans).

The subjective effects associated with the congruent condition are particularly interesting because substantial research suggests that in this condition participants do often read the word instead of color name but may be unaware of this (cf., MacLeod, 1991; MacLeod & MacDonald, 2000), perhaps because outputs from word-naming and color-naming processes are identical. We refer to this interesting insensitivity as *double-blindness*, because one seems to be unaware that two distinct processes have occurred when those processes lead to identical action plans (Morsella et al., in press). With respect to the Stroop task, MacLeod and MacDonald (2000) state, "The experimenter (perhaps the participant as well) cannot discriminate which dimension gave rise to the response on a given congruent trial" (p. 386). Double-blindness may also be featured in the congruent conditions of flanker and countermanding tasks, such as the antisaccade task (Curtis & D'Esposito, 2009; Husain et al., 2003). In general, the notion of double-blindness is consistent with the view that one is conscious only of the outputs of processes, not of the processes themselves (Lashley, 1951).

Following training, participants were informed that, when estimating their urge-to-err, what they were "looking inside their minds and measuring" was a psychological state known as "activity." To minimize experimental demand effects, we defined the concept of *activity* only in terms of the participant's Stroop task experience and offered no further information about the concept: "*What you were measuring inside your mind when estimating your urge to make a mistake is a psychological state called 'activity.' When your urge to make a mistake on this task was high, activity was high; when your urge to make a mistake on this task was low, activity was low.*" Thus, participants learned to introspect not the general tendency to err on a task but the specific urge or feeling that happens to be associated with interference on the Stroop task, in which incompatible plans play a role (Cohen et al., 1990). They were then told that they would later be asked to measure, not their urge-to-err, but specifically this kind of "activity" in a novel task. No participant had difficulty understanding the concept of activity: All participants responded in the affirmative to the question, "Do you understand the concept of activity?" It is important to note that we could have just as well called this dimension of interest something as arbitrary as "H5" or "Titchener Energy," for the construct was defined only by the participant's own experience. We selected the term *activity* only because it is unbiased and intuitive.

Subsequently, in a *sustained intentions* task, participants rated activity while sustaining basic identical, compatible, or incompatible intentions. In Study 1, compatible intentions consisted of reaching a button and a form of wiggling with the same arm (analogous to a goalie preparing to leap and catch simultaneously; Figure 1B), and incompatible intentions consisted of reaching distant buttons with the same arm (analogous to a goalie preparing to leap both right and left; Figure 1A). The former was deemed compatible because one could both reach a button and wiggle simultaneously (i.e., both actions are "coexpressible"; Figure 1C). In contrast, the latter is physically impossible (Figure 1A). According to the hypothesis, similar subjective effects should accompany even the least dramatic of skeletomotor actions, because such effects stem from a processing dynamic (activation of incompatible plans) and not from the difficulty of executing an action. In Study 2, compatible intentions consisted of pressing a button with a finger and "wiggling and hovering"; incompatible intentions consisted of using a single finger to press separate buttons. We predicted that, with both effector systems,[4] participants would report more activity while sustaining incompatible as compared to compatible or identical intentions. In addition, in a control study

[4] Participants in each study used only one effector system for all actions, because piloting (n = 14) revealed that this paradigm becomes overly confusing if responding involves switching from one effector (e.g., the vocal apparatus) to another (e.g., the arm).

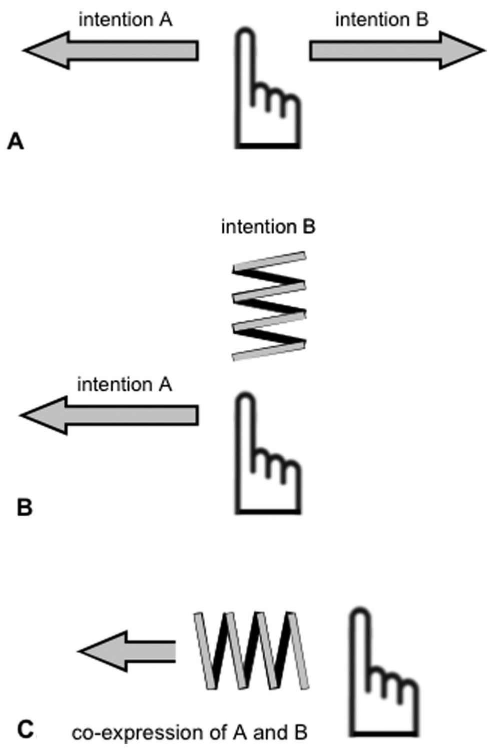

Figure 1. A. Scenario in which one sustains diametrically opposed (incompatible) intentions. Intention A (reaching left) and B (reaching right) cannot be "coexpressed." B. Scenario in which one sustains the intentions to perform A (reaching left) and B (vibrate or wiggle the finger), action plans that, hypothetically, are coexpressible, as illustrated in C, in which it is shown that one could reach left while vibrating or wiggling the effector.

focusing on a smooth muscle effector system, we took the further step to examine the corollary hypothesis that increases in activity should not arise under conditions of conflict outside of the skeletomotor system.

STUDY 1

Methods

Participants. Eighteen Yale University students participated for $8.

Procedure. Participants were run individually in two training phases and a test phase. After introspection training (Appendix I. B), participants were trained to perform actions with their right arm when cued by colored rectangles (7.5 × 3.8 cm) on a black background. In Studies 1 and 2, stimulus presentation was controlled by PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993), and stimuli were presented on a 43 cm Apple eMac computer monitor (60 Hz) with a viewing distance of approximately 48 cm. Depending on the color, participants (a) reached leftward and pressed a button of a PsyScope button box (Model 2.02; New Micros; Dallas, TX) located 34 cm left of and 34 cm behind the keyboard, (b) reached rightward and pressed the mouse button (34 cm right of and 34 cm behind the keyboard), or (c) raised and wiggled their arm in a specified manner (see Figure 2). Participants were told that, to aid their readiness and speed, on each trial a warning prompt (spanning 2 s) would identify the targets 11 s beforehand.

For the wiggling action, participants were instructed, "Release your hand from rest position by slightly lifting your arm; extend your fingers and keep your palm parallel with the table; then momentarily wiggle your hand," by rotating it on the axis of the wrist (Figure 2, right). The experimenter then verified that the participant could perform the action, which lasted roughly 4 s. If the performance was incorrect, the experimenter demonstrated how to perform the action correctly.

Each of the 30 cued action training trials proceeded as follows. After participants indicated their readiness by pressing the space bar with their right hand when confronted with a "Ready?" prompt, and a subsequent delay of 1.5 s, one of three action-related prompts (yellow, green, or red rectangles) appeared for 2 s. After a delay of 11 s, the target appeared, which was always identical to the prompt. Target types appeared an equal number of times and in random order. After the response, or a timeout of 3 s, the next trial began after 700 ms. When not responding to targets or "Ready?" prompts, participants kept their right hand in a comfortable rest position (a fist-like posture, with fingers parallel to the table) on a wrist-pad immediately before the keyboard.

Participants then performed the sustained intentions task. They were told that the procedure would be similar to that of training except that prompts (now spanning 1 s) may be ambiguous (two different colors), signaling that each of the two cues is equiprobable as a target and that they should prepare to perform either action as quickly as possible. Participants were encouraged to be in a state of readiness. Of the 54 randomized trials, there were 12 *incompatible*, 12 of each kind of *compatible* (reach rightward-wiggle; reach leftward-wiggle), and 18 *identical* prompts (wiggle; wiggle). Prompts were presented in random order. Participants were questioned about activity randomly, on half (27) of the trials. To get an accurate measure of their action-related subjective state, in introspection trials, participants were questioned about activity at the same point in time (11 s following the prompt) that targets would normally appear, using a 1 to 8 scale, in which 1 signified "no activity" and 8 signified "extreme activity." After their response, and a delay of 2.5 s, the target appeared. Following a response or a timeout of 3 s, the next trial began after 700 ms. Trials on which no ratings took place proceeded in the same manner except that targets appeared at the moment that questioning would appear. For the time course of two sample trials, see Figure 3.

Results. Stroop-task RTs below 200 ms and above 2.5 s were excluded from analysis, resulting in the data loss of 8 (1.5%) out of 528 trials. ANOVA analyses revealed that Stroop condition had systematic effects on RTs (replicating the Stroop effect), $F(2, 42) = 35.656$, $p < .0001$, and on urge-to-err ratings $F(2, 42) = 63.53$, $p < .0001$ ($\eta_p^2 = .75$). As predicted, urge-to-err was greatest for the incongruent ($M = 4.48$, $SEM = .28$), followed by control (e.g., HOUSE presented in green; $M = 2.84$, $SEM = .25$) and congruent conditions ($M = 1.47$, $SEM = .13$), *PLSD*, ps $< .0001$.

The low urge-to-err rating reported for the congruent condition may be an instance of double-blindness and warrants further investigation. Eighteen of the 22 participants had significant

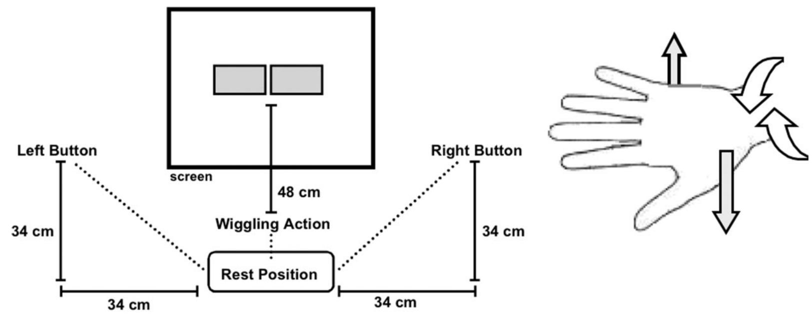

Figure 2. The experimental set-up, including the distances between rest position and the target buttons (left). Schematic depiction of the wiggling action from Study 1 (right).

within-person correlations (rs $\geq$ .46, ps $<$ .05) between RT and ratings. We used Fisher zr to estimate the population correlation between RT and the urge-to-err (based on 24 trials) and it was also significant (zr = .587, p $<$ .01). These findings suggest that participants may have based their urge-to-err judgments on RTs. Aggregating across all 22 participants, the mean correlation coefficients between RTs and urge-to-err judgment within each condition ($r_{\text{congruent}}$ = .377, r_{control} = .430, $r_{\text{incongruent}}$ = .454) were positive and significantly different from zero (ps $<$ .01). However, the Fisher zrs to estimate the population correlations between RT and the urge-to-err within each condition (based on eight trials) were each nonsignificant (p $>$ .05), probably due to the low power.

For the sustained intentions task, an ANOVA revealed there was a main effect of condition on subjective activity, $F(3, 51)$ = 32.322, p $<$ .0001 (Figure 4A). Planned comparisons revealed that each of the four means depicted in Figure 4A was significantly different from each of the other means (all ps $<$ .01, except for the contrast between the two compatible conditions, p $<$ .05). When analyzing just the three ambiguous conditions, the same pattern of results is obtained, $F(2, 34)$ = 19.274, p $<$ .0001 (η_p^2 = .53). Planned comparisons revealed differences in activity between the ambiguous conditions (ps $<$ .05). Only one of 18 participants yielded opposite results. Response accuracy was high (Ms $>$ 95%) in this and the subsequent study, and button-press RTs (the only RTs that were recordable) toward targets revealed no effect from compatible versus incompatible prompts (ps $>$ .50). During a postexperimental interview, all participants reported that they had introspected the same "thing" that they had during the Stroop task (Appendix I.A). We believe that this stemmed from the incompatibility of the plans involved. If activity reflected the difficulty rather than incompatibility of sustained plans, then compatible conditions should have yielded the most activity, for the wiggling action was

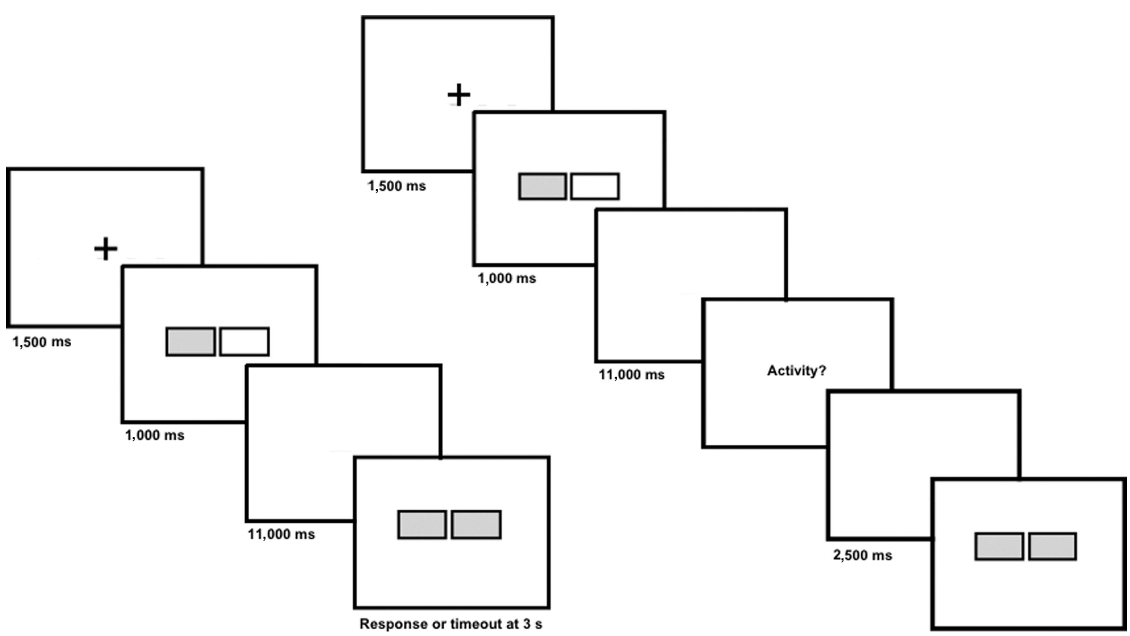

Figure 3. Schematic representation of a nonintrospection (left) and introspection (right) trial during the sustained intentions task.

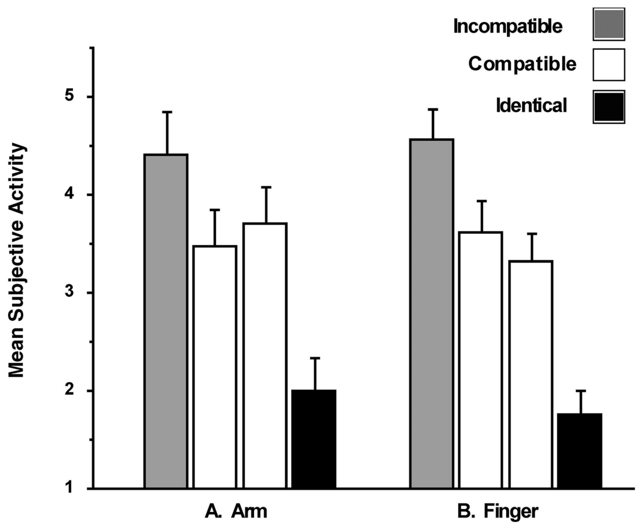

Figure 4. A. Subjective activity from intentions involving gross actions of the arm. (Compatibles: reach rightward with wiggle; reach leftward with wiggle.) B. Subjective activity from sustained intentions involving fine actions of a finger. (Compatibles: rightward button-press with hover-wiggle; leftward button-press with hover-wiggle.) Error bars indicate *SEM*s.

considered by independent judges ($n = 8$) to be more difficult than button-pressing: on an 8-point scale, *M*s = 3.00 vs. 2.12, t_{paired} (7) = 2.966, $p = .02$.

STUDY 2

The gross arm movements of Study 1 captured the goalie's predicament, but changes in subjective experience are predicted to accompany all kinds of skeletomotor conflicts, even those involving finer gesticulations. Study 2 evaluated whether movements of a single finger lead to comparable effects. The strong prediction is that the size of the effector system is not crucial to the degree of experienced conflict, and so activity ratings should be roughly of the same magnitude, whatever the effector. Analogous to the three actions from Study 1, incompatible intentions consisted of pressing separate buttons (one on the left and one on the right) with the same finger; compatible intentions consisted of (a) "hovering and slightly wiggling" the finger in a specified manner, and (b) pressing a button.

Methods

Participants. Fourteen Yale University students participated for $8.

Procedures. The procedures were identical to those of Study 1 except that the delay between prompts and targets was shortened to 4.5 s and the task involved a different kind of motor response. During resting position, the finger depressed the central of three buttons on the button box. Depending on the color of the cue, participants either (a) released the central button, slid their finger leftward (3 cm) and clicked the button on the left, (b) clicked the button 3 cm on the right with a similar motion, or (c) released the central button and "hovered and slightly wiggled" their index finger over the box. A similar procedure to that of Study 1 was used to instruct participants to wiggle their fingers and to correct for inaccurate performances, except that participants were also instructed, "Release the central button by slightly lifting your left index finger; then hover and slightly wiggle or vibrate the finger." This time, the vibration was more of an up and down motion, spanning roughly 3 s. In addition, the sustained intentions task involved fewer trials: participants were queried about activity on 18 of the 36 trials. Of these, there were four incompatible, four of each kind of compatible, and six identical prompts. Hover-wiggling was judged by independent judges ($n = 8$) to be more difficult than button-pressing: on an 8-point scale, *M*s = 3.62 versus 2.25, t_{paired} (7) = 3.667, $p < .01$.

Results. For training, the RT trimming procedure of Study 1 led to the removal of 11 (3.3%) out of 336 trials. The overall results mirrored those of Study 1, including the Stroop urge-to-err ratings, $F(2, 26) = 59.995$, $p < .0001$, and the mean within-person correlation between RT and ratings ($r = .633$, $p < .01$). Again, the mean correlation coefficients between RTs and urge-to-err judgment within each Stroop condition ($r_{\text{congruent}} = .306$, $r_{\text{control}} = .239$, $r_{\text{incongruent}} = .533$) were positive and the congruent and incongruent conditions were significantly different from zero ($ps < .05$). The mean within-person correlation for the control condition approached significance ($p = .08$). Again, the Fisher *zrs* to estimate the population correlations between RT and the urge-to-err within each condition (based on eight trials) were each nonsignificant ($p > .05$).

Again, for the sustained intentions task, an ANOVA revealed there was a main effect of condition on subjective activity, $F(3, 39) = 43.919$, $p < .0001$ (Figure 4B). Planned comparisons revealed that each of the four means depicted in Figure 4B was significantly different from each of the other means ($ps < .01$), except for the contrast between the two compatible conditions ($p = .0691$). When analyzing just the three ambiguous conditions, the same pattern of results is obtained, $F(2, 26) = 26.085$, $p < .0001$ ($\eta_p^2 = .53$). Only 1 of 14 participants yielded data that were in the opposite direction.

CONTROL STUDY

To examine the corollary hypothesis that such subjective effects are peculiar to conflicts involving the skeletomotor system, we conducted a comparison study in which participants who had received introspection training reported activity while undergoing an innocuous form of action conflict involving the smooth muscle system. Specifically, participants ($n = 14$) reported activity while expressing the pupillary light reflex under conditions of conflict and no conflict. This reflex is elicited by conditions as diverse as changes in light level, arousal, and point of focus. Regardless of light conditions, both pupils are always matched in diameter. When one eye is covered, the pupil of the other dilates; when it is then uncovered, the pupil of the other constricts. Pupillary dilation and constriction are mediated by different, antagonistic divisions of the autonomic nervous system.[5] Constriction (mediated by the sphincter muscle fibers of the iris) is under the control of the parasympathetic nervous system, and dilation (mediated by the radial muscle fibers of the iris) is under the control of the sympathetic nervous system (Bartley, 1951; Dodd & Role, 1991; Gardner, 1975; Tortora, 1994). Under normal circumstances, pupil size reflects the simultaneous actions of, and interplay between, the sphincter and radial muscle fibers of the iris (Sinnatamby, 2006). *Intraeffector* conflict (Bartley & Chute, 1947) ensues when the pattern of light stimulation activates both constriction and dilation within short time intervals (Bartley, 1943, 1951; Dodd & Role, 1991). In this way, a flickering light can lead to strain, fatigue, and health problems (Bartley & Chute, 1947). Discomfort arises from "some degree of simultaneous activity in opposing muscle systems" (Bartley, 1942, p. 373). A more innocuous form of nonskeletal muscle conflict occurs when light is shone in only one eye.[6]

During the experiment, participants were seated comfortably while peering through makeshift viewing tubes.[7] Participants answered several questions and rated "activity" while under the conflict and no conflict conditions. For the no conflict condition (synchronized dilation), the experimenter occluded both of the apertures of the tubes and immediately asked the subject to rate how much activity was experienced as a result of the change on a 1 to 8 scale, in which 1 signified *no activity* and 8 signified *extreme activity*. For the conflict condition, the experimenter occluded only one of the apertures, thereby eliciting to some extent both dilation through radial muscles and constriction through sphincter muscles (Bartley, 1942; Tortora, 1994), and immediately asked the subject to rate activity. The experimenter jotted down this number as well as the participant's responses to additional questions (see Appendix II). Based on our hypothesis (and, perhaps more importantly, as suggested by everyday experience in which people never seem to experience the urge to constrict or dilate pupils), we predicted that participants would not report more activity for the conflict condition (details in Footnote 5). Indeed, as is clear in Appendix II, this is exactly what we found, t_{paired} (13) = .898, p = .3854 (η_p^2 = .06). This study also illustrates the inherent multidimensionality of subjective experience, which prompted us to develop a form introspection training for Study 1. For example, some aspects of the participant's experience (e.g., the high degree of awareness about the change in light conditions; third question in Appendix II) were influenced by the manipulation, but other aspects (e.g., low amount of activity) were not influenced to the same degree, $F(1, 13) = 392.019$, $p < .0001$ (η_p^2 = .97).

The overall pattern of results is captured in an omnibus 2 × 2 mixed design ANOVA on these data and those from Study 2. In this analysis, activity was the dependent measure, effector type (skeletal or smooth muscle) was a between-subjects factor, and conflict condition (conflict or no conflict) was a within-subjects factor. (For the "no conflict" skeletomotor data, we collapsed data from the two compatible conditions.) There was a main effect of effector type, $F(1, 13) = 42.367$, $p < .0001$ ($\eta_p{}^2$ = .77), in which more activity was reported for the skeletal muscle effector, and a main effect of conflict condition, $F(1, 13) = 38.426$, $p < .0001$ (η_p^2 = .75), in which, overall, more activity was reported for the conflict condition. More important, there was a significant interaction between effector-type and conflict condition, $F(1, 13) = 34.148$, $p < .0001$ (η_p^2 = .73), in which conflict led to significantly more reported activity only in the skeletal muscle condition, $t(13) = 6.209$, $p < .0001$. Indeed, in the control study, mean activity for the conflict and no conflict conditions was very similar (*M*s = 1.36 and 1.31, respectively).

General Discussion

Why do some forms of conflict (holding one's breath or inhibiting a prepotent response in a laboratory task) lead to changes in consciousness, while no such changes accompany the many other forms of conflict in the nervous system? To address this question and illuminate the essence of conscious conflict, we developed a paradigm to test the hypothesis that the mere activation of incompatible skeletomotor intentions in-and-of-itself triggers subjective effects. As predicted, merely sustaining such incompatible intentions in a motionless state produced stronger systematic changes in subjective experience than sustaining compatible intentions, for both gross and fine actions. This is consistent with the general observation that conflicts occurring at perceptual/conceptual levels of processing (e.g., stimulus interference, intersensory conflicts) tend not to perturb subjective experience as do conflicts occurring at response selection levels of processing (Morsella et al., in press; van Veen et al., 2001), whether in approach-avoidance conflicts, the delay of gratification, response interference tasks, or the Stoop task.

The hypothesis is based on a theory regarding the *primary* (certainly not *the only*) function of consciousness (Morsella, 2005), a function that is intimately related to action production. However, the present data cannot be used to rule out the possibility that perturbations in consciousness can also stem from purely

[5] Specifically, "during the pupillary light reflex, in response to a bright light, the parasympathetic input is activated and the sympathetic dilator system is inhibited, causing a net decrease in pupillary diameter. Pupillary dilation results from increasing tonic activity in sympathetic neurons and decreasing activity in parasympathetic neurons" (Dodd & Role, 1991, p. 773).

[6] Under these conditions, the unoccluded pupil dilates but less so than it would if both eyes were exposed to equal darkness (Thompson, 1947), due to the actions of the light-stimulated sphincter muscles, which counter those of the radial muscles. Regarding such an interocular interaction and how it is corrected through mechanisms such as the reciprocal innervation between the antagonistic muscles of the iris, Bartley (1942) states, "Pure reciprocal inhibition, though common, is only approximated in many cases, and it is conceivable that reciprocity could breakdown completely under certain . . . conditions" (p. 372), such as those involving challenging patterns of stimulation (e.g., simultaneous activation of the tendency to dilate and constrict the pupil).

[7] Each participant was run individually. It was verified that each participant was capable of expressing the *direct pupillary reflex* and the *consensual pupillary reflex*. For the former, the experimenter simply inspected visually whether each pupil reduced in size in response to a mild, harmless light. For the latter, the experimenter verified whether such changes occur as well in the pupil that was not exposed to light. To diminish experimental demand, this took place after the experiment. The participant underwent each condition five times, for a total of 10 trials. For each participant, the conditions were presented in random order.

mental conflicts.[8] In addition, we provided initial (but far from conclusive) support for the corollary hypothesis that no such effects arise from conditions of action conflict involving a smooth muscle effector system. Future investigations, perhaps involving stronger forms of smooth muscle effector conflict, will be necessary to further examine this corollary hypothesis. One value of this study is that it opens the door to better tests of this challenging corollary hypothesis.

Unlike standard interference tasks, the sustained intentions task isolated the primary subjective effects of incompatible intentions from their secondary effects. We believe that this theoretically predicted liaison between the activation of incompatible action plans and these subjective effects is the primary seed giving rise to the changes in subjective experience during hot action conflicts. In our paradigm, participants learned about *activity* only experientially, through a training process in which the urge-to-err presumably reflects, among other things (e.g., effort and arousal), conflict between action plans (Cohen et al., 1990). Thus, we were able to train participants to "tune in" to the conflict-related aspects of their subjective experience. It is interesting to note that during training, participants were capable of introspecting aspects of a cognitive process as fleeting as color-naming, an act lasting less than one second. Although it is known that participants cannot introspect their own RTs at this time scale (Libet, 2004; but see recent evidence to the contrary, Corallo, Sackur, Dehaene, & Sigman, 2008), it cannot be ruled out that they were basing their judgments on RTs. However, such an account cannot explain the results of the critical task, in which introspection took place without action. The similar results from studies 1 and 2 corroborate that these effects depend on the incompatibility of the plans involved and not the size or difficulty of the associated actions.

Limitations of the Current Approach and Future Directions

A major assumption of our approach is that sustaining motor intentions activates to some extent the motor plans used to behaviorally express those intentions (Chambers & Mattingley, 2005; Curtis & D'Esposito, 2009; Rizzolatti et al., 1987) and that coactivation of incompatible plans occurred more often while participants were instructed to sustain incompatible than compatible intentions. Conflicting action plans involving the same effector (e.g., the arm) can today be activated only through the presentation of sensory stimuli that stimulate both plans. (One day this may be achieved innocuously by something like transcranial magnetic stimulation, TMS.) In this way, the strongest subjective effects have been found in conditions involving incompatible plans, whether in the Stroop task, variants of the flanker task (Morsella et al., in press), or in the current paradigm, which strives to provide an instantiation of incompatible plans with minimal secondary effects (e.g., minimal suppression or need deprivation). A project involving something like TMS may one day instantiate such an effect in a cleaner and more direct manner, one without the shortcomings of the present studies.

Although participants confirmed that they were reporting the same "thing" that they had experienced in training (Appendix I.A), as with other introspective measures (Block, 2007), it is challenging to verify what participants were introspecting *at the moment* that they were making their activity judgments. It is clear that retrospective reports (as in Appendix I.A) about conscious states are far from infallible, even if they occur just seconds after the relevant conscious experience (Block, 2007). It is also clear that judgments may have been influenced by factors like arousal and effort (Kahneman, 1973): The incompatible conditions in both our Stroop and sustained intentions task may have been more effortful or arousing than the compatible intentions, and this alone could have led to our findings. Ruling out this alternative hypothesis depends in part on learning more about the nature of cognitive effort, which is itself a complicated construct (Preston & Wegner, 2009; Rosen et al., 2007; Sanders, 1983).

As with other introspective measures, "activity" is inherently ambiguous. Even in flanker studies that probe the nature of the "fuzzy" and fleeting conflict-related states by asking about perceptions of control and competition on a trial-by-trial basis (Morsella et al., in press), it remains difficult to ascertain what participants are actually doing when introspecting. For example, one could argue that participants' reliable judgments were based, not on their experience of conflict, but on their folk beliefs about cognition and its conflicts.[9]

For the benefit of future investigation, in informal exploratory discussions following the experiment, some participants likened the incompatible condition of the sustained intentions task to a traffic jam, short circuit, or bottleneck, because "both actions can't get through at the same time," as one participant put it (Appendix I.A). When participants were reminded that targets never actually summoned more than one action at a time, they seemed amused and a handful replied something to the effect of, "yes, but mentally preparing [incompatible] actions was the most peculiar." For good reason, these retrospective reports must be taken with a grain of salt (Block, 2007). As with double-blindness (which may have occurred to some extent in

[8] That such mental events are still intimately related to action is best captured by Thorndike's (1905) assertion, "The function of thoughts and feelings is to influence actions. . . Thought aims at knowledge, but with the final aim of using the knowledge to guide action" (p. 111).

[9] The present studies cannot rule out that activity ratings stemmed from folk beliefs regarding psychological experiments. However, this alternative cannot explain (without difficulty) why participants' ratings tended to vary across trials within each condition. For instance, for the incompatible trials, the ratings from a participant selected at random from Study 1 were 7, 7, 8, 8, 5, and 4 (mean *SD*s for each condition of Study 1 were $.89_{Incompatible}$, $.77_{Compatible1}$, $.78_{Compatible2}$, and $.96_{Identical}$). Moreover, participants' reports can be corroborated to some extent by the fact that activity ratings from the incompatible prompts (M_{Study1} = 4.57, M_{Study2} = 4.55) and Stroop incongruent stimuli (M_{Study1} = 4.48, M_{Study2} = 4.60) were similar, but different from those of the conflict condition of the control study (M = 1.56). The alternative hypothesis also cannot explain why no differences were found between the conflict and no conflict conditions of the control study, in which one could argue that demand characteristics could generate data based on folk beliefs. It should be noted, however, that the differences between the control and experimental studies are probably too many for one to draw these kinds of conclusions regarding the possibility of artifacts from experimental demand.

the identical conditions of Studies 1 and 2),[10] they serve as interesting anecdotes to spur further investigation.

Valence From Conflict

Are the subjective effects of sustaining incompatible intentions experienced as positive or as negative? The answer to this question is of great interest to students of emotion. Although at this stage of understanding there may be no straightforward answer (because the valence of these effects may depend on background levels of neural excitation and homeostatic mechanisms concerned with optimal levels of arousal; Kahneman, 1973; Sanders, 1983), given recent theoretical and empirical developments, it seems that these effects are more likely to acquire a negative rather than a positive valence.

First, there is a good theoretical basis for proposing that it would be adaptive for an organism to avoid situations of conflict and thus generate a negative valence to conflict-related stimuli (Bargh & Morsella, 2008; Botvinick, 2007; Livnat & Pippenger, 2006; Morsella, 2005). Second, it has been demonstrated that people prefer situations and stimuli that require little mental effort or response interference/conflict (Botvinick, 2007; Rosen et al., 2007; Winkielman et al., 2003). For example, Beilock and Holt (2007) showed that skilled typists prefer letter strings that, when typed using standard typing methods, engender little or no motor interference (e.g., *FJ* would be preferred over *FV*). It is interesting to note that typists were unaware of the motoric-based reason for their preference. In addition, Fenske and Raymond (2006) have demonstrated that neutral visual stimuli (e.g., abstract patterns) can acquire a negative valence if they must be ignored or suppressed, which involves activation of incompatible action plans. Hence, one could venture to propose that the incongruent condition in the Stroop task is more likely to engender negative affect than the congruent condition. Indeed, there is some preliminary evidence supporting this (Morsella & Bargh, 2008). Consistent with these findings, 93.8% of our participants from studies 1 and 2 claimed that the incompatible condition was the one condition that they would least want to experience for extended periods of time (Appendix I.A). Nevertheless, it is clear that further research is necessary to better understand the valence dimension of these elusive effects.

At this stage of understanding, perhaps it is enough to say that we have supported a theoretical approach that, consistent with the many observations involving various kinds of conflicts in the nervous system—"hot" (e.g., holding one's breath), less "hot" (e.g., flanker response interference), and impenetrable (e.g., McGurk effect)—predicts when conflicts will (and will not) intrude upon subjective experience. More generally, it is our hope that this enterprise will help open a window into the systematic study of the ineffable "tuggings and pullings" of everyday life and its liaisons with cognitive control and affect. With this paradigm and by targeting brain regions involved in cognitive control and conflict (e.g., prefrontal and anterior cingulate cortices; Botvinick et al., 2001), future research may identify the neural correlates of these subjective effects and assess their role in negative affect (e.g., anxiety) and failures of self-regulation, where incompatible tendencies play a critical role (Baker et al., 2006; Baumeister & Vohs, 2004).

[10] It is important to note that, in both studies, the identical conditions yielded the lowest levels of subjective activity. As revealed in Figure 4, this activity was appreciable lower than that of the compatible conditions ($ps < .01$). This most likely reflects the fact that participants construed (or mentally recoded) the two cues signaling the same action (e.g., "reach left" *and* "reach left," or "wiggle" *and* "wiggle") as a single cue commanding one action, leading to as much activity as would be experienced after being presented with prompts during the cued action training session. More interestingly, as may occur in the congruent conditions of the Stroop or countermanding tasks (e.g., the prosaccade condition in the antisaccade task), the lack of reportable changes in consciousness may reflect a form of double-blindness. In this case, the two cues do activate two action plans (or, more conservatively, more action-related processes than would occur during cued action training); however, the participant is unaware of this because identical or highly similar action plans lead to little or no detectable changes in consciousness (Morsella, 2005). Again, this would be consistent with the notion that, for the most part, one is only conscious of the outputs of processing (Lashley, 1951) and of discrepancies occurring at late (response-selection) stages of processing (Morsella, 2005). Further investigation is required to determine whether the effect from the identical condition is an instance of double-blindness.

References

Baker, T. B., Japuntich, S. J., Hogle, J. M., McCarthy, D. E., & Curtin, J. J. (2006). Pharmacological and behavioral withdrawal from addictive drugs. *Current Directions in Psychological Science, 5,* 232–236.

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

Bargh, J. A., & Morsella, E. (2008). The unconscious mind. *Perspectives on Psychological Science, 3,* 73–79.

Bartley, S. H. (1942). A factor in visual fatigue. *Psychosomatic Medicine, 4,* 369–375.

Bartley, S. H. (1943). Conflict, frustration and fatigue. *Psychosomatic Medicine, 5,* 160–162.

Bartley, S. H. (1951). The psychophysiology of vision. In S. S. Stevens (Ed.), *Handbook of experimental psychology* (pp. 921–984). New York: Wiley.

Bartley, S. H., & Chute, E. (1947). *Fatigue and impairment in man.* New York: McGraw-Hill.

Baumeister, R. F., & Vohs, K. D. (2004). *Handbook of self-regulation: Research, theory, and applications.* New York: Guilford Press.

Beilock, S. L., & Holt, L. E. (2007). Embodied preference judgments: Can likeability be driven by the motor system? *Psychological Science, 18,* 51–57.

Block, N. (2007). Consciousness, accessibility, and the mesh between psychology and neuroscience. *Behavioral and Brain Sciences, 30,* 481–548.

Botvinick, M. (2007). Conflict monitoring and decision making: Reconciling two perspectives on anterior cingulate function. *Cognitive, Affective and Behavioral Neuroscience, 7,* 356–366.

Botvinick, M. M., Braver, T. S., Carter, C. S., Barch, D. M., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108,* 624–652.

Brown, J. W., & Braver, T. S. (2005). Learned predictions of error likelihood in the anterior cingulate cortex. *Science, 307,* 1118–1121.

Bush, G., Shin, L. M., Holmes, J., Rosen, B. R., & Vogt, B. A. (2003). The multi-source interference task: Validation study with fMRI in individual subjects. *Molecular Psychiatry, 8,* 60–70.

Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin, 115,* 401–423.

Chambers, C. D., & Mattingley, J. B. (2005). Neurodisruption of selective attention: Insights and implications. *Trends in Cognitive Sciences, 9,* 542–550.

Cohen, J. D., Dunbar, K., & McClelland, J. L. (1990). On the control of automatic processes: A parallel distributed processing account of the Stroop effect. *Psychological Review, 97,* 332–361.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavior Research Methods, Instruments, & Computers, 25,* 257–271.

Corallo, G., Sackur, J., Dehaene, S., & Sigman, M. (2008). Limits on introspection: Distorted subjective time during the dual-task bottleneck. *Psychological Science, 19,* 1110–1117.

Crick, F. (1995). *The astonishing hypothesis: The scientific search for the soul.* New York: Touchstone.

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

Curtis, C. E., & D'Esposito, M. D. (2009). The inhibition of unwanted actions. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer (Eds.), *Oxford handbook of human action* (72–97). New York: Oxford University Press.

DeSoto, M. C., Fabiani, M., Geary, D. C., & Gratton, G. (2001). When in doubt, do it both ways: Brain evidence of the simultaneous activation of conflicting responses in a spatial Stroop task. *Journal of Cognitive Neuroscience, 13,* 523–536.

Dodd, J., & Role, L. W. (1991). The autonomic nervous system. In E. R. Kandel, J. H. Schwartz, & T. M. Jessell (Eds.), *Principles of neural science* (3rd ed., pp. 761–775). New York: Elsevier.

Eriksen, C. W., & Schultz, D. W. (1979). Information processing in visual search: A continuous flow conception and experimental results. *Perception and Psychophysics, 25,* 249–263.

Fenske, M. J., & Raymond, J. E. (2006). Emotional influences of selective attention. *Current Directions in Psychology, 15,* 312–316.

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive attention and metacognitive regulation. *Consciousness and Cognition, 9,* 288–307.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Gardner, E. (1975). *Fundamentals of neurology* (6th ed.). Philadelphia: W. B. Saunders.

Glenberg, A. M. (1997). What memory is for. *Behavioral & Brain Sciences, 20,* 1–55.

Gray, J. A. (2004). *Consciousness: Creeping up on the hard problem.* New York: Oxford University Press.

Harmon-Jones, E., & Harmon-Jones, C. (2002). Testing the action-based model of cognitive dissonance: The effect of action-orientation on post-decisional attitudes. *Personality and Social Psychology Bulletin, 28,* 711–723.

Higgins, E. T. (2005). Value from regulatory fit. *Current Directions in Psychological Science, 14,* 209–213.

Husain, M., Parton, A., Hodgson, T. L., Mort, D., & Rees, G. (2003). Self-control during response conflict by human supplementary eye field. *Nature Neuroscience, 6,* 117–118.

Jacoby, L. L., Kelley, C. M., & Dywan, J. (1989). Memory attributions. In H. L. Roediger & F. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 391–422). Hillsdale, NJ: Erlbaum.

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

Johnson, M. K., & Raye, C. L. (1981). Reality monitoring. *Psychological Review, 88,* 67–85.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice Hall.

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

Lewin, K. (1935). A dynamic theory of personality. New York: McGraw-Hill.

Libet, B. (2004). *Mind time: The temporal factor in consciousness.* Cambridge, MA: Harvard University Press.

Livnat, A., & Pippenger, N. (2006). An optimal brain can be composed of conflicting agents. *Proceedings of the National Academy of Sciences, USA, 103,* 3198–3202.

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

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109,* 163–203.

MacLeod, C. M., & McDonald, P. A. (2000). Interdimensional interference in the Stroop effect: Uncovering the cognitive and neural anatomy of attention. *Trends in Cognitive Sciences, 4,* 383–391.

Mayr, U. (2004). Conflict, consciousness, and control. *Trends in Cognitive Sciences, 8,* 145–148.

Mayr, U., Awh, E., & Laurey, P. (2003). Conflict adaptation effects in the absence of executive control. *Nature Neurosciences, 6,* 450–452.

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

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

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

Mischel, W., & Metzner, R. (1967). Preference for delayed reward as a function of age, intelligence, and length of delay interval. *Journal of Abnormal and Social Psychology, 64,* 425–431.

Morsella, E. (2005). The function of phenomenal states: Supramodular interaction theory. *Psychological Review, 112,* 1000–1021.

Morsella, E. (2009). The mechanisms of human action: Introduction and background. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer, *Oxford handbook of human action* (pp. 1–32). New York: Oxford University Press.

Morsella, E., & Bargh, J. A. (2008). *Valence from conflict.* Unpublished manuscript, Yale University.

Morsella, E., & Bargh, J. A. (in press). Unconscious action tendencies: Sources of "un-integrated" action. In J. T. Cacioppo & J. Decety (Eds.), *Handbook of social neuroscience.* New York: Oxford University Press.

Morsella, E., Wilson, L. E., Berger, C. C., Honhongva, M., Gazzaley, A., & Bargh, J. A. (in press). Subjective aspects of cognitive control at different stages of processing. *Attention, Perception, and Psychophysics.*

Mulert, C., Menzinger, E., Leicht, G., Pogarell, O., & Hegerl, U. (2005). Evidence for a close relationship between conscious effort and anterior cingulate cortex activity. *International Journal of Psychophysiology, 56,* 65–80.

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

Passingham, R. (1995). *The frontal lobes and voluntary action.* New York: Oxford University Press.

Preston, J., & Wegner, D. M. (2009). Elbow grease: The experience of effort in action. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer (Eds.), *Oxford handbook of human action* (pp. 469–486). New York: Oxford University Press.

Reis, D. L., & Gray, J. R. (2009). Affect and action control. In E. Morsella, J. A. Bargh, and P. Gollwitzer (Eds.), *Oxford handbook of human action* (pp. 277–297). New York: Oxford University Press.

Rizzolatti, G., Riggio, L., Dascola, I., & Umiltá, C. (1987). Reorienting attention across the horizontal and vertical meridians: Evidence in favor of a premotor theory of attention. *Neuropsychologia, 25,* 35–40.

Rosen, Z. V., McGuire, J., & Botvinick, M. M. (2007). Is mental effort aversive? Some behavioral and psychophysiological evidence. Paper presented at 14th Annual Meeting of the Cognitive Neuroscience Society.

Sanders, A. F. (1983). Towards a model of stress and human performance. *Acta Psychologica, 53,* 61–97.

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, 362,* 773–786.

Sinnatamby, C. S. (2006). *Lasts's anatomy: Regional and applied.* New York: Churchill Livingston.

Stevens, S. S. (1956). The direct estimation of sensory magnitudes: Loudness. *American Journal of Psychology, 69,* 1–25.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.
Thompson, L. C. (1947). Binocular summation within the nervous pathways of the pupillary light reflex. *Journal of Physiology, 106,* 59–65.
Thorndike, E. L. (1905). The functions of mental states. In E. L. Thorndike (Ed.), *The elements of psychology* (pp. 111–119). New York: A. G. Seiler.
Tortora, G. J. (1994). *Introduction to the human body: The essentials of anatomy and physiology* (3rd ed.). New York: Harper Collins.
van Veen, V., & Carter, C. S. (2006). Conflict and cognitive control in the brain. *Current Directions in Psychological Science, 15,* 237–240.
van Veen, V., Cohen, J. D., Botvinick, M. M., Stenger, V. A., & Carter, C. C. (2001). Anterior cingulate cortex, conflict monitoring, and levels of processing. *Neuroimage, 14,* 1302–1308.
Vroomen, J., & de Gelder, B. (2003). Visual motion influences the contingent auditory motion aftereffect. *Psychological Science, 14,* 357–361.
Winkielman, P., Schwarz, N., Fazendeiro, T., & Reber, R. (2003). The hedonic marking of processing fluency: Implications for evaluative judgment. In J. Musch & K. C. Klauer (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion* (pp. 189–217). Mahwah, NJ: Erlbaum.

Appendix I

Post-Session Retrospective Data and Introspection Training

A. *Post-Session Retrospective Data from Informal Interviews*: Before debriefing, each participant responded in the affirmative to the following questions: "When you received the ambiguous, mixed color prompts, did you prepare to perform either action?" and "Did you introspect the same 'thing' for both the color naming task and the subsequent task?" Then they were asked the question, "Which prompt scenario would you least want to experience for extended periods of time?" The experimenter then reminded the participants of all the color-combinations constituting the prompt scenarios. All participants from Study 1 and 12/14 from Study 2 selected the incompatible condition. (The only other condition that was selected was the compatible [the wiggle-and-move left condition] from Study 2). The experimenter then informally inquired about the reasons for this choice and about overall impressions that participants had about the incompatible condition and the sustained intentions task.

B. *Introspection training*: For Studies 1 and 2, the eight colors used were correctly identified by all participants. In the incongruent condition, targets (colors) and distracters (words) were re-paired systematically (e.g., if RED was written in blue then BLUE was written in red). Participants were instructed to name the color in which the word was written as quickly and as accurately as possible. On each trial, a ready prompt (question mark) appeared onscreen until participants indicated that they were ready to proceed by pressing the space bar. Thereafter, a fixation point (+) was shown at the center of the screen for 1.5 s. It was followed by a blank screen (700 ms), after which time a randomly selected Stroop stimulus appeared (48-point Helvetica), remaining onscreen until a vocal response was made. Responses were detected by microphone (Model 33–3014; Radio Shack; Fort Worth, TX) connected to the PsyScope button box. After the response and 700 ms, participants were asked, "How strong was the urge to make a mistake?" Then they rated this question on an 8-point scale, in which 1 signified *almost no urge* and eight signified *extremely strong urge*. Thereafter, the next trial began after 500 ms.

Appendix II

Information for the Control Study

Question	Conflict		No conflict	
	M	*SEM*	*M*	*SEM*
Activity?[a]	1.36	0.26	1.31	0.22
Are you aware of the current circumstances?[b]	7.80	0.20	7.93	0.07
Are you aware that there was a change in lighting conditions?	7.83	0.17	7.99	0.01
Do you feel that you acted (did something) in response to the change in lighting conditions?	1.46	0.32	1.30	0.20
How strong was the activity associated with the action you made in response to the change in lighting conditions?	1.36	0.28	1.20	0.14

[a] Participants rated activity using a 1 to 8 scale, in which 1 signifies *no activity* and 8 signifies *extreme activity.* [b] Based on Folstein, Folstein, & McHugh (1975). Participants answered this and the subsequent three questions using a 1 to 8 scale, in which 1 equals *not at all* and 8 equals *extremely so.*

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