Selective suppression of the incorrect response implementation in choice behavior assessed by transcranial magnetic stimulation

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Abstract

Selecting the adequate alternative in choice situations may involve an inhibition process. Here we assessed response implementation during the reaction time of a between-hand choice task with single- or paired-pulse (3 or 15 ms interstimulus intervals [ISIs]) transcranial magnetic stimulation of the motor cortex. The amplitude of the single-pulse motor evoked potential (MEP) initially increased for both hands. At around 130 ms, the single-pulse MEP kept increasing for the responding hand and decreased for the nonresponding hand. The paired-pulse MEP revealed a similar pattern for both ISIs with no effect on short intracortical inhibition and intracortical facilitation measures. The results suggest that the incorrect response implementation was selectively suppressed before execution of the correct response, preventing errors in choice context. The results favor models assuming that decision making involves an inhibition process.

Descriptors: Action selection, Human, Motor control, RT, Two-alternative forced choice

One of the most distinctive features of human motor control is the ability to adapt behavior quickly to environmental demands. In our everyday life, we constantly receive external stimuli to which we do or do not have to react. However, the relation between a stimulus and a response is not one to one: The same stimulation can lead to a different response depending on the context, our current goals, or both. Thus goal-direct responses involve the selection of the appropriate behavior and the organization of the operations in a coherent way so that the stimulus will be efficiently translated into action. These operations can be investigated in the choice reaction time (RT) paradigm. In this situation, the task explicitly requires the selection of one response among response alternatives.

Models of forced-choice tasks principally rely on choosing between two alternatives. Such models assume that evidence favoring one alternative is integrated over time with a discrete or continuous accumulation until a threshold is reached that triggers the selected response (e.g., Ratcliff & Smith, 2004). A main difference between the models is the way that evidence for one alternative is integrated relative to the other alternative. In one type, the pure race models, evidence for each alternative is integrated independently in two accumulators (e.g., Cohen, Dunbar, & McClelland, 1990). In contrast, in another type, evidence for each alternative is not integrated independently. Indeed, for the diffusion models, the difference between the two alternatives is integrated in a single accumulator (e.g., Ratcliff, Van Zandt, & McKoon, 1999). For the competition with inhibition models, the evidence for each alternative is integrated in two accumulators with an inhibition process modulating the integration performed by the accumulators (e.g., Usher & McClelland, 2001). In these models, the inhibition process acting on an accumulator can come directly from the other accumulator (lateral or mutual inhibition) or come from an element upstream of the two accumulators (feed-forward inhibition). According to Bogacz, Brown, Moehlis, Holmes, and Cohen (2006), all models except the pure race models can be formally reduced to a drift diffusion model, meaning that the diffusion models and the competition with inhibition models cannot be distinguished based on their behavioral predictions. The response competition models, although assuming that evidence for both alternatives is initially integrated, differ according to the way the competition takes place thereafter (i.e., by involving or not an inhibition process). In the pure race models, the increase of evidence for the selected alternative (i.e., the first that reaches the threshold) is accompanied by an increase of evidence for the nonselected alternative that becomes less pronounced with time. In contrast, in the competition with inhibition models, the evidence for the nonselected alternative decreases before the evidence for the
selected alternative reaches the threshold. An open question is whether such an inhibition process can affect the response implementation. The present study investigates whether the motor implementation of the nonselected response is initiated and then suppressed. To this end, the neural dynamics of motor implementation for both the selected and the nonselected responses was assessed by transcranial magnetic stimulation (TMS) of the motor cortex.

TMS can be used to assess excitatory and inhibitory intracortical circuits within the motor cortex (see Reis et al., 2008, for a review). Pulses passing through a wire coil placed over the scalp induce brief electrical currents to the brain. When applied to the primary motor cortex, single-pulse TMS can cause a small twitch in the muscle controlled by the stimulated area. The physiological effect of TMS can be quantified by measuring the motor-evoked potential (MEP) with surface electromyographic (EMG) techniques. The MEP amplitude obtained with single-pulse TMS reflects the net effect of excitatory and inhibitory inputs to the corticospinal pathway. During tonic voluntary muscle contraction, TMS can suppress the EMG activity; the duration of the late part of this silent period is thought to reflect cortical inhibitory mechanisms. In the paired-pulse TMS paradigm, two separate pulses are delivered to the motor cortex through the same TMS coil (Kujirai et al., 1993). Short interstimulus intervals (ISIs; 2–5 ms) are used to assess short intracortical inhibition (SICI), the first subthreshold (conditioning) pulse being thought to recruit intracortical inhibitory interneurons that reduce the MEP amplitude produced by a second suprathreshold (test) pulse (Di Lazzaro et al., 1998; Kujirai et al., 1993; Nakamura, Kitagawa, Kawaguchi, & Tsuji, 1997). Paired-pulse TMS with longer ISIs (10–15 ms) may be used to provide a measure of intracortical facilitation (ICF; Kujirai et al., 1993).

The inhibition process has been investigated in tasks where participants are instructed to respond to a “go” stimulus by producing a particular movement and to withhold that movement when a “no-go” or “stop” stimulus is presented. In these go/no-go tasks, corticospinal excitability has been shown to increase after the go stimulus and decrease after the no-go stimulus around 150 ms following stimulus presentation (Hoshiyama et al., 1996, 1997). The amplitude of the MEP evoked with paired-pulse TMS (2-ms ISI) is also reduced in a no-go situation (Sohn, Wiltz, & Hallett, 2002) and in the voluntary termination of a planned movement (Coxon, Stinear, & Byblow, 2006), consistent with increased activity in intracortical inhibitory circuits. When a stop signal is presented shortly after the go stimulus on some trials (stop tasks), corticospinal excitability has been shown to decrease around 180 ms after the stop signal (van den Wildenberg et al., 2010). Moreover, a lengthening of silent period duration evoked by single-pulse TMS was found following the instruction to stop, suggesting an increased recruitment of intracortical inhibitory circuits within the motor cortex (van den Wildenberg et al., 2010). Thus there is evidence that different intracortical inhibitory circuits play a role in tasks involving explicit stopping of ongoing behavior.

In choice RT tasks, although there is no explicit instruction to stop a movement, previous studies suggest involvement of an inhibition process (see Burle, Vidal, Tandonnet, & Hasbroucq, 2004, for a review). The H-reflex was found to increase for the responding hand and to decrease for the nonresponding hand before the movement initiation in a between-hand choice reaction time task (Hasbroucq, Akamatsu, Burle, Bonnet, & Possamaï, 2000). This pattern has also been observed in EMG activity, indicating that suppression can occur on the motoneuronal pool (Tandonnet, Burle, Vidal, & Hasbroucq, 2005). This suppression observed at the spinal level is compatible with inhibitory inputs to the corticospinal pathway. Event-related potential (ERP) studies using surface Laplacian estimation to enhance the spatial resolution of the recorded activity over the sensorimotor cortices have provided evidence for cortical inhibition. These studies revealed that the negativity developing over the cortex contralateral to the response is accompanied by a positivity developing over the ipsilateral cortex (Tandonnet, Burle, Vidal, & Hasbroucq, 2003; Taniguchi, Burle, Vidal, & Bonnet, 2001; Vidal, Grapperon, Bonnet, & Hasbroucq, 2003), a pattern focused over the primary sensorimotor cortex (Tandonnet, Burle, Hasbroucq, & Vidal, 2005). The negativity preceding the voluntary movement likely reflects the implementation of the correct response, and the activity with an opposite polarity developing in the same time range and in the same location area may reflect a suppression of the incorrect response implementation (Burle et al., 2004; see Vidal et al., 2003, for a review). In one study, the silent period evoked by single-pulse TMS was found to increase for the nonresponding hand following stimulus presentation, reflecting involvement of cortical inhibitory circuits within the motor cortex (Burle, Bonnet, Vidal, Possamaï, & Hasbroucq, 2002). These previous studies suggest that an inhibition process may play a key role in choice RT tasks by modulating motor implementation of the responses and preventing the incorrect response from occurring.

If the motor implementation of the nonselected response is suppressed during between-hand choice tasks, it should be visible in the variations of excitability of the final motor pathway. However, previous studies using single-pulse TMS of the motor cortex during between-hand choice RT tasks did not support this notion. The MEP elicited by single-pulse TMS was found to increase in either hand after stimulus presentation (Burle et al., 2002; McMillan, Ivry, & Byblow, 2006). The MEP was also found to increase more for the responding hand than for the nonresponding hand at some point during the reaction time period (Duque & Ivry, 2009; Koch et al., 2006; Leocani, Cohen, Wassermann, Ikoma, & Hallett, 2000). These patterns are compatible with the view that, after an initial phase in which both possible responses are implemented, the correct response receives further activation than the incorrect one. Thus previous TMS studies found no decrease of the MEP for the incorrect response, providing no clear evidence for a suppression of the incorrect motor implementation.

The objective of the present study was to address whether the motor implementation of the nonselected response can be suppressed during a between-hand choice task. To this end, we assessed motor implementation of both the responding hand and the nonresponding hand with TMS. We used MEP amplitude obtained with single-pulse TMS of the motor cortex as a global measure of the ongoing response implementation representing the net effect of excitatory and inhibitory synaptic inputs on the final motor pathway. We used MEP amplitude obtained with paired-pulse TMS with 3 ms and 15 ms ISI (Kujirai et al., 1993) as a measure of SICI and ICF. To allow tracking of the dynamics, TMS was delivered at several possible intervals between stimulus presentation and response execution. We hypothesized that (i) if both responses are implemented in a first phase, the single-pulse MEP amplitude would increase for both hands, (ii) if the motor implementation of the incorrect response is suppressed in a second phase, the single-pulse MEP amplitude would decrease for
the nonresponding hand prior to movement initiation, and (iii) if such suppression involves an increase of SICI or a decrease of ICF, the decrease in amplitude of the single-pulse MEP for the nonresponding hand would be more pronounced for the conditioned MEPs (3 ms or 15 ms ISI).

Methods

Participants
Twelve participants (8 women and 4 men, aged 18–36 years, mean = 25, SD = 7) were healthy volunteers with self-reported right-handedness and normal or corrected-to-normal vision. Informed written consent was obtained according to the Declaration of Helsinki, and the study was approved by the University of Tasmania Human Research Ethics Committee.

Behavioral Setup
Participants were seated in a comfortable chair in a darkened room with supports for forearms and hands. The hands were held in a neutral position with the thumbs resting on the top of two vertical cylinders with mounted force sensors fixed on the table approximately 30 cm in front of participants. Participants faced a black panel, 80 cm distant at eye level. A horizontal row of three light-emitting diodes (LEDs) were positioned at the center of the panel; the two outer LEDs were 4 cm apart. The central LED (green) served as a fixation point and the two outer LEDs (yellow) were the response signals.

Trial Events
Each trial started with illumination of the central fixation LED. After 500 ms, the fixation was switched off and the imperative stimulus consisting of one of the two outer yellow LEDs was switched on for 500 ms. Participants were instructed to execute as quickly as possible the isometric thumb press that was spatially compatible with the stimulus location (e.g., left press for a stimulus on the left of fixation). After termination of the stimulus, a feedback signal was presented. If the first press exceeding 4 N was on the correct side during the 500 ms following stimulus presentation, the feedback was a short auditory “click” (1000 Hz, 50 ms in duration); otherwise it was a longer “buzz” (400 Hz, 200 ms in duration). The intertrial interval was 800 ms.

Design
Participants performed a training session without TMS and then an experimental session with TMS. Each block comprised 56 trials in which each imperative stimulus (left/right) occurred 28 times in a random sequence. In the training session, EMG was recorded and blocks of trials were performed until the error rate was below 0.05 and the coefficient of variation of response latencies was below 0.15 during two consecutive blocks. In the experimental session of 12 blocks, TMS was delivered at the stimulus presentation or at four other possible times individually determined from the EMG onset latencies of the responses performed with the left hand (i.e., when the right hand was not responding) in the last two blocks of the training session. One TMS time was at the imperative stimulus onset (t1) and the four other times were around the first decile of the EMG onset distribution: at one third before (t2), at one sixth before (t3), at the first decile (t4), and at one sixth after (t5; see Figure 1 for the TMS times relative to the EMG onset distribution of the non-
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intensity was held constant throughout the experiment. Mean resting motor threshold was 47% ($SD = 9$) of the maximal stimulator output. Mean test stimulus intensity was 56% ($SD = 11$) of the maximal stimulator output. Mean conditioning stimulus intensity was 30% ($SD = 6$) of the maximal stimulator output, corresponding to 63% ($SD = 8$) of resting motor threshold.

**EMG and Force Recordings**

Surface EMG activity was recorded from paired Ag/AgCl electrodes fixed over the FPB muscle in a belly tendon montage. The EMG signal was amplified with a gain of 1000, filtered using a 50-Hz notch filter, 20-Hz high-pass and 500-Hz low-pass (Butterworth, 12 dB/octave) filters, and digitized online at a sampling rate of 2 kHz (16-bit resolution; CED 1902, Cambridge Electronic Design, UK). The force signal was filtered using a 50-Hz notch filter and a 100-Hz low-pass (Butterworth, 12 dB/octave) filter, and digitized online at 2 kHz (16-bit resolution; CED 1902, Cambridge Electronic Design, UK).

### Results

**Response Latency**

There was no difference between left and right hands on either response latencies, $t(11) = 1.17, p = .27$, or EMG onset latencies, $t(11) < 1$. The mean reaction time for the no-TMS trials was 286 ms ($SD = 57$). The mean EMG onset latency was 189 ms ($SD = 29$); the deciles of these distributions are presented with respect to the times of TMS delivery (Figure 1).

**MEP Amplitude**

The mean amplitude of the raw MEPs for single-pulse TMS and paired-pulse TMS with 3-ms and 15-ms ISIs was 0.81 mV, 0.49 mV, and 0.91 mV, respectively. The mean MEP amplitudes ($z$ scores) are presented in Figure 2. There was an effect of time, $F(3,33) = 27.07, p < .001, \epsilon = .85$, showing that corticospinal excitability tends to increase during the reaction time period. The MEP was larger for the responding condition than for the nonresponding condition, $F(1,11) = 16.38, p < .01$. This effect confirmed that the execution of the selected movement is preceded by an increase of corticospinal excitability for the response contralateral to the stimulated cortex. There was an effect of TMS type, $F(2,22) = 29.59, p < .001, \epsilon = .76$, indicating that paired-pulse TMS with a 3-ms ISI elicited smaller MEP amplitude than the MEP obtained with single-pulse TMS. The two-way interaction between time and responding hand, $F(3,33) = 23.46, p < .001, \epsilon = .74$, revealed that the effect of time was different when the right hand was responding than when it was the nonresponding hand. The effect of time was linear for the responding condition ($p < .01$), and both the linear and the quadratic components were significant for the nonresponding condition ($ps < .05$). Post hoc tests revealed that the MEP amplitudes for the nonresponding condition significantly increased until around 130 ms (TMS times t1 vs. t2, $p = .03$; t2 vs. t3, $p < .01$) and then decreased before movement initiation (i.e., between t3 and t4, $p = .03$). Importantly, there was no interaction between TMS type and the two other factors, time, $F(6,66) < 1, \epsilon = .92$, or hand, $F(2,22) < 1, \epsilon = 1.00$, and the three-way interaction was not significant, $F(6,66) < 1, \epsilon = .71$, revealing that the MEP pattern obtained with paired-pulse TMS (3-ms and 15-ms ISIs) was similar to that obtained with single-pulse TMS.
The paired-pulse MEP amplitudes expressed relative to the single-pulse MEP amplitudes revealed no significant modulation (Figure 3). The ratio for the paired-pulse TMS with a 3-ms ISI showed no difference between responding and nonresponding conditions, $F(1,11) < 1$, no effect of time, $F(3,33) = 1.11$, $p = .36$, $\varepsilon = 1.00$, and no interaction, $F(3,33) = 1.69$, $p = .19$, $\varepsilon = 1.00$. Similar statistical results were obtained for the 15-ms ISI, $F(1,11) < 1$; $F(3,33) = 1.36$, $p = .28$, $\varepsilon = .76$; $F(3,33) < 1$, $\varepsilon = 1.00$, respectively.

The variations in amplitude of the MEP obtained with single-pulse TMS showed that corticospinal excitability increased first nonspecifically and then either kept on increasing when the right hand was about to respond or decreased when the right hand was not responding. The early nonspecific MEP increase is in line with previous studies (Burle et al., 2002; McMillan et al., 2006). These results are compatible with the notion that implementation of both responses are initiated in between-hand choice reaction time tasks. The dissociation between the responding and nonresponding conditions observed later in the reaction time period is also consistent with previous TMS studies (Duque & Ivry, 2009; Koch et al., 2006; Leocani et al., 2000). The new result of the present study is that the MEP was found to decrease for the nonresponding condition around 130 ms after stimulus presentation. The MEP decrease likely reflects a selective mechanism (i.e., response-specific) that keeps increasing the activation of the selected response and decreases the activation of the nonselected response. This mechanism can be viewed as an “active” suppression of the ongoing implementation of the incorrect response in two-choice reaction time tasks or may reflect a “passive” suppression following the initial activation (i.e., a return to baseline). These two possible interpretations of the suppression mechanism are discussed in the following. We first present how the MEP suppression observed with single-pulse TMS extends previous studies, then discuss the possible neural mechanisms involved in the suppression mechanism based on the paired-pulse MEP modulations and on previous results, and finally assess to what extent the present results can challenge the current models of choice tasks.

**Selective MEP Suppression during Choice Reaction Time**

The MEP dissociation between the two hands has been observed in previous studies using choice tasks, but, to our knowledge, no significant MEP decrease for the nonresponding hand was reported during RT (Duque & Ivry, 2009; Koch et al., 2006; Leocani et al., 2000). The bilateral MEP increase in the early RT has been observed in one previous study (Burle et al., 2002). The
apparent discrepancy in the literature may be resolved by the present study, where both nonselective and selective contributions were observed. These MEP modulations suggest that two mechanisms act concurrently on corticospinal excitability. If the nonselective activation is superimposed on the suppression component of the selective activation/suppression mechanisms, the nonselective component may potentially mask the selective one, depending on the relative weight and timing of the two components. This potential confound may explain why the MEP for the nonresponding hand was not found to decrease during RT in the above mentioned previous studies. Note also that even in the study showing a clear bilateral increase during RT, there was a nonsignificant decrease for the nonresponding hand for the last stimulation (Burle et al., 2002, p. 213, Figure 6). Thus one cannot exclude that a lack of statistical power in that previous study led to the apparent discrepancy with the present results. A more critical factor may be the specific times of TMS delivery. Indeed, the density of stimulation times preceding the EMG onset was higher in the present study than in the Burle et al. (2002) study. As for the nonresponding hand, the MEP tends to first increase quite sharply (between t2 and t3) and then decrease with the same sharpness (between t3 and t4, see Figure 2), it seems likely that the higher density of TMS times just before response execution in the present study allowed observation of the dynamics of such activation/suppression modulations. Importantly, such rapid changes in the dynamics favor the interpretation of these modulations as an active suppression mechanism.

**Possible Neural Mechanisms Involved in the Selective Suppression**

A suppression of the incorrect motor output in choice tasks is compatible with a previous study showing a reduction in EMG activity (Tandonnet, Burle, Vidal, et al., 2005). The brief reduction of tonic EMG activity in the hand involved in the incorrect response suggests that the suppression mechanism can affect the activity of the motoneuronal pool. A reduction of the H-reflex has also been found for the incorrect response in a between-hand choice task, perhaps reflecting modulation of presynaptic inhibition on the motoneurons’ somesthetie afferents (Hashbroucq et al., 2000). However, such modulations may involve a population of motoneurons different from that involved in the MEP (Petersen, Pyndt, & Nielsen, 2003). Hence the H-reflex modulations may not necessarily reflect the same mechanism responsible for the MEP variations observed in the present study. In the present study, the mean MEP amplitude in the nonresponding hand was found to decrease before the mean EMG onset derived from no-TMS trials, suggesting that the suppression of the incorrect response implementation can be initiated before the execution of the correct response starts.

To test the involvement of different cortical circuits within the motor cortex, we used paired-pulse TMS. The paired-pulse MEP with 3-ms and 15-ms ISIs revealed a pattern similar to that exhibited by single-pulse MEP, with both SICI and ICF measures showing no significant modulation. Note that test TMS intensity was maintained constant at 120% RMT throughout the experiment to assess SICI modulations in accordance with the recommendation of Garry and Thomson (2009). Thus, in the present experiment, the paired-pulse TMS assessed the dynamics of the same cortical circuits for all stimulation times, likely including those generating the late I-waves (I2, I3; Di Lazzaro et al., 1998; Garry & Thomson, 2009). The lack of difference in SICI for the responding and nonresponding conditions suggests that the observed corticospinal modulations did not involve the intracortical circuits assessed with paired-pulse TMS (3- and 15-ms ISIs).

The present results, therefore, suggest that decreased SICI or increased ICF for the responding hand is not a prerequisite for the implementation of the selected response. Likewise, it also appears that the suppression mechanism may not involve increased SICI or decreased ICF for the nonresponding hand. However, previous ERP studies have provided evidence for cortical inhibitory mechanisms operating during choice RT tasks. By using surface Laplacian estimation to enhance spatial resolution, these studies have revealed an activation/suppression pattern over the sensorimotor cortices prior to movement initiation (Tandonnet, Burle, Hasbroucq, et al., 2005; Tandonnet et al., 2003; Taniguchi et al., 2001; Vidal et al., 2003). Evidence for suppression of the incorrect response has also been shown in silent period duration, suggesting the involvement of intracortical inhibitory circuits (Burle et al., 2002). As excitatory and inhibitory inputs to the corticospinal pathway influence MEP amplitude, we can speculate that the MEP pattern observed in the present study may reflect cortical modulations like those observed through variation of the silent period duration. This interpretation is in line with the explanation offered to account for the dissociation between response activation and stopping processes observed in a stop task (van den Wildenberg et al., 2010). That is, it was proposed that the recruitment of intracortical inhibitory circuits as revealed by silent period modulations was responsible for the subsequent decline in corticospinal excitability in stop tasks (van den Wildenberg et al., 2010). Cortical inhibition is thought to be influenced by gamma-aminobutyric acid (GABA)-ergic inhibition with modulation of the cortical silent period duration being mediated by GABA_B receptors (Siebner, Dressnanndt, Auer, & Conrad, 1998; Werhahn, Kunesch, Nocachtar, Benecke, & Classen, 1999) and SICI by GABA_A receptors (Ziemann, Lönnecker, Steinhoff, & Paulus, 1996). ICF may be influenced by GABAergic inhibition through GABA_A receptors and glutamate-ergic facilitation through N-methyl-D-aspartate (NMDA) receptors (see Ziemann, 2004, for a review). The present results raise the possibility that the corticospinal suppression observed involves different cortical circuits than SICI and ICF circuits. Rather the suppression may specifically involve other intracortical inhibitory circuits like those mediated by GABA_B receptors. The corticospinal reduction may also be linked to changes in connectivity between the dorsal premotor cortex and the motor cortex, as these changes can be independent of intracortical circuits involved in SICI and ICF within the motor cortex (Koch et al., 2006). This leads to the speculation that the inhibition process involved in choice reaction time tasks may be more specific than those involved in tasks explicitly involving the stopping of an ongoing behavior (go/no-go and stop tasks). This possibility suggests that the physiological mechanisms involved in response inhibition critically depend on the specific context of the task.

**Implication of the Selective Suppression for the Models of Choice Tasks**

In what follows, we assess how the present data can challenge the different models of choice tasks. We consider more particularly how the dynamic of the motor implementation of the responses can constrain both the way the evidence in favor of one alternative is accumulated and the link between this decision process and the motor implementation of the responses. As stated in the introduction section, we assume that the MEP modulations...
reflect the net effect of excitatory and inhibitory inputs to the corticospinal pathway and thus can be used as an index of the motor implementation of the responses.

The nonselective increase of MEP in the early RT is assumed to reflect an initial bilateral activation of the responses. For models with two accumulators, the minimalist assumption that the motor implementation of the responses depends only on the accumulation of evidence for each alternative predicts this MEP pattern. Indeed, an increase of evidence for each alternative would lead to a motor implementation of both responses. In contrast, models with a single accumulator assume by definition that only evidence for the difference between the two alternatives can increase, which cannot lead to motor implementation of both responses without further assumption. An assumption compatible with the present data would be that the motor implementation of the responses depends also on a response activation process that is independent of the decision process, possibly triggered by the mere occurrence of the imperative stimulus. This assumption is in line with dual-route architectures (De Jong, Liang, & Lauber, 1994; Kornblum, Hasbroucq, & Osman, 1990). In this framework, the stimulus conveys both the attribute relevant for selecting the correct alternative and other attributes irrelevant for the task. The relevant attribute would activate the correct response via a controlled route, whereas the irrelevant attributes may activate the incorrect response via an automatic route. Thus the nonselective increase of MEP observed in the present study is compatible with two-accumulator models and may also be compatible with single-accumulator models with the additional assumption of a response activation process independent of the decision process.

The specific MEP decrease obtained only for the nonresponding hand later in the RT period is assumed to reflect a selective suppression of the activation of the nonselected response. Note that this reduction may a priori be viewed either as an “active” suppression of the ongoing response implementation or as a “passive” suppression following the initial activation. Models with two independent accumulators assume an increase of evidence for the nonselected alternative that would lead to an increase of activation of the nonresponding hand. In contrast, in models with two accumulators assuming an inhibition process, evidence for the nonselected alternative can decrease, leading to a suppression of the motor implementation of the nonselected response. For models with a single accumulator, the predictions depend on the link between the decision process and the motor implementation of the responses. If an increase of evidence for one alternative leads to an activation of the implementation of the selected response, it cannot lead to any decrease in the activation of the nonselected response. However, the decision process may also lead to a suppression of the initial activation of the nonselected response through an inhibition process. The specific MEP decrease for the nonresponding hand revealed in the present study nicely fits the predictions of the models assuming an inhibition process but is difficult to reconcile with models assuming two independent accumulators and models assuming a single accumulator without an inhibition process.

Thus the dynamics of the response implementation as reflected by MEP modulations provide some constraints on models of choice tasks concerning the way the evidence is integrated and on the link between this decision process and the motor implementation of the responses. The present data are compatible with decision-making models assuming two accumulators with an inhibition process but not with models assuming two independent accumulators (pure race models). These data are also compatible with single accumulator models (diffusion models) with the following assumptions: (i) a nonselective activation process independent of the decision process and (ii) an inhibition process of the implementation of the nonselected response. The inhibition process assumed by the different models takes place at different levels. For the models assuming two accumulators with inhibition, the inhibition process acts on the accumulators (decision process), whereas for the single accumulator models the inhibition process acts on the response implementation. Further research is needed to address to what extent the inhibition process can be specific to decision making or response implementation processes. Importantly, the fact that the present data are compatible only with the predictions of models assuming an inhibition process favor an interpretation of the MEP decrease as an active suppression mechanism.

Conclusion
The present results showed that MEP amplitude first increases during RT for both the responding and the nonresponding hand and then decreases in the nonresponding hand. These results suggest that after an initial facilitation of both responses, ongoing implementation of the incorrect response was selectively suppressed before initiation of the correct response execution. This selective suppression may secure the correct response implementation by preventing errors in choice behavior. These results favor models of choice tasks assuming an inhibition process.

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