Cognition 127 (2013) 264–269

Contents lists available at SciVerse ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Brief article

When errors do not matter: Weakening belief in intentional control impairs cognitive reaction to errors

Davide Rigoni [a,b,c,*], Hélène Wilquin [d], Marcel Brass [b,e], Boris Burle [a]

[a] Laboratoire de Neurosciences Cognitives, CNRS: UMR7291, Aix-Marseille University, France
[b] Department of Experimental Psychology, Ghent University, Belgium
[c] Department of General Psychology, University of Padova, Italy
[d] Laboratoire Parole et Langage, CNRS: UMR7309, Aix-Marseille University, France
[e] Behavioural Science Institute, Radboud University Nijmegen, The Netherlands

ARTICLE INFO

Article history:
Received 31 May 2012
Revised 28 January 2013
Accepted 29 January 2013
Available online 1 March 2013

Keywords:
Free will
Post-error slowing
Belief
Action monitoring
Intention
Cognitive control

ABSTRACT

The belief that one can exert intentional control over behavior is deeply rooted in virtually all human beings. It has been shown that weakening such belief – e.g. by exposure to 'anti-free will' messages – can lead people to display antisocial tendencies. We propose that this cursory and irresponsible behavior may be facilitated by a breakdown of neurocognitive mechanisms underlying behavioral adjustments. In the study reported here, we tested the hypothesis that weakening belief in intentional control reduces cognitive markers of behavioral control. Participants performed a Simon task before and after reading a scientific text either denying free will (no-free will group) or not mentioning free will (control group). Results showed that the post-error slowing, a cognitive marker of performance adjustment, was reduced in the no-free will group. This reduction was proportional to a decrease of the belief in intentional control. These observations indicate that weakening the belief in free will can impact behavioral adjustment after an error, and could be the cause of antisocial and irresponsible behavior.

1. Introduction

In many everyday-life situations we evaluate the impact of our actions and adjust them according to external constraints, such as environmental changes, or internal states, such as desires and intentions. This capacity to exert voluntary control over behavior is crucial for the adaptation to the external environment and also for successful interactions with other individuals (Baumeister, Crescioni, & Alquist, 2011). Empirical data support the idea that the belief that we can voluntarily control our behavior is a biological need and is adaptive for survival (for an overview see Leotti, Iyengar, & Ochsner, 2010).

Belief in intentional control can be weakened after exposing individuals to deterministic messages that deny free will (Baumeister, Masicampo, & DeWall, 2009; Rigoni, Kühn, Gaudino, Sartori, & Brass, 2012; Rigoni, Kühn, Sartori, & Brass, 2011; Vohs & Schooler, 2008). Empirical observations from social psychology also show that reducing belief in intentional control can have negative effects on the way people behave, namely by reducing pro-social and altruistic attitudes and by increasing antisocial and aggressive behavior (Baumeister et al., 2009; Vohs & Schooler, 2008). It has been proposed that a loss of self-control – i.e. the capacity to override one's impulses (Baumeister, Bratslavsky, Muraven, & Tice, 1998) – plays a crucial role in leading to such behavioral changes (Baumeister et al., 2009; Rigoni et al., 2012). More specifically, the exposure to a deterministic message would weaken people's motivation to exert self-control. Since self-control requires individuals to make an effort and spend energy, as

* Corresponding author. Address: Ghent University, Department of Experimental Psychology, 2 Henri Dunantlaan, 9000 Gent, Belgium. Tel.: +32 491080812.
E-mail address: davide.rigoni@ugent.be (D. Rigoni).

0010-0277/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cognition.2013.01.009

indicated by increased blood glucose level (Gailliot & Baumeister, 2007; Gailliot et al., 2007), a lack of motivation would lead people to go for more automatic and impulsive courses of action (Baumeister et al., 2009).

Recently, a novel approach has been proposed to assess which parts of the information processing chain are affected by the belief manipulation (Rigoni et al., 2011, 2012). This research investigates how basic neurocognitive processes underlying voluntary behavior are affected by whether people believe they can exert intentional control. It has been found that the Readiness Potential, a neurophysiological marker of intentional action preparation, can be reduced when people are led to disbelieve in free will (Rigoni et al., 2011). Disbelieving in free will also reduces voluntary motor inhibition and the feeling of having deliberate control over a motor action (Rigoni et al., 2012). Taken together, these findings suggest that it is possible to reduce individuals' belief in intentional control, and that weakening belief in intentional control may lead to a degradation of basic motor processes underlying voluntary actions.

Here we present an experiment in which we tested whether reducing belief in intentional control can affect a specific aspect of intentional control, namely action monitoring. Action monitoring can be described as the ability to evaluate the adequacy and success of a performance (see Ridderinkhof, van den Wildenberg, Segalowitz, and Carter (2004) for an overview). How people retrospectively evaluate their actions is crucial to determine future behavior, as well as whether they feel responsible for the consequences of their behavior. Irresponsible and impulsive behavior following exposure to anti-free will messages may result from a breakdown in the evaluation of the consequences of behavior. Since dismissing intentional control leads to cursory and irresponsible behavior (Baumeister et al., 2009; Vohs & Schooler, 2008) and to less intentional involvement in the task (2012; Rigoni et al., 2011), we wanted to test whether monitoring of action effects is reduced by exposure to anti-free will messages.

Experimentally, action monitoring is often investigated by use of conflict tasks (e.g. Stroop task, Simon task, Eriksen-flanker task). For instance, in the Simon task (see Simon, 1990 for a review) participants respond with left- or right-hand key press according to the color of a stimulus presented either on the left or on the right of a fixation point. A conflict occurs when response and stimulus location are incongruent, e.g. when a stimulus that requires a right-hand response is presented on the left of the fixation point. In these tasks, action monitoring processes can be assessed by studying "sequential effects", that is, how performance on trial n is affected by the performance on trial $n-1$. While large sequential effects reflect, at least partly, an appropriate action monitoring (Kerns et al., 2004), absent or diminished sequential effects reveals a degraded action monitoring. For instance, after an error subjects are typically slower (Rabbitt, 1966). This post-error slowing effect indicates a reaction to an error and is thought to partially reflect involvement of control processes (Botvinick, Braver, Barch, Carter, & Cohen, 2001; but see Notebaert et al., 2009). Thus, a large post-error slowing reflects an appropriate action monitoring (Kerns et al. 2004), whereas absent or diminished post-error slowing reveals a degraded action monitoring. Diminished post-error slowing has been observed in patients with schizophrenia (Alain, McNeely, He, Christensen, & West, 2002; Carter, MacDonald, Ross, & Stenger, 2001; Kerns et al., 2005), children with ADHD disorder (Jonkman, van Melis, Kemner, & Markus, 2007; Schachar et al., 2004; Sergeant & van der Meere, 1988; Wiersema, van der Meere, & Roeyers, 2005), whereas one study reported an increased post-error slowing in obsessive–compulsive patients (Fitzgerald et al., 2005; but see Hajcak & Simons, 2002).

Taken together, these findings suggest that processes underlying behavioral adjustment may be disrupted in clinical conditions where intentional control is impaired. Our main prediction is that exposing participants to an anti-free will message that weakens the role of intentional control will impair action monitoring processes. We expect that the reduction of action monitoring mechanisms will be associated with a decrease in the belief in intentional control. To measure the belief in intentional control, we employed the Free Will and Determinism-Plus scale (FAD-Plus; Paulhus & Carey, 2011). The FAD-Plus includes items concerning distinct aspects of beliefs about intentional control, such as beliefs in free will ("*People have complete control over decisions they make*"), scientific ("*As with other animals, human behavior always follows the laws of nature*") as well as fatalistic determinism ("*Fate already has a plan for everyone*"), and unpredictability of human behavior ("*What happens to people is a matter of chance*").

2. Method

2.1. Participants

Forty-four university students (30 females, 14 males), aged 18–32 years ($M = 21.7 \pm 2.8$) volunteered for this experiment, provided informed consent, and were paid 15 euros for participation. The study was conducted according to the Declaration of Helsinki and was approved by the local ethic committee of Aix-Marseille I University, and by the "Comité de Protection des Personnes Sud Méditerranée 1" (number 10 41).

2.2. Experimental design and procedure

The experimental design was divided in a baseline and a post-manipulation session. Further details on the experimental procedure, the task, and ancillary self-report measures are reported in the supplementary material.

2.2.1. Baseline session

First, each participant completed at home the FAD-Plus (Paulhus & Carey, 2011), that measures the belief in intentional control. This scale is composed by 27 Likert-type items (scores ranging from 1 = totally disagree, to 5 = totally agree) and includes 4 subscales (Free Will, Scientific Determinism, Fatalistic Determinism, and Randomness). At least one week after, an experimental session was organized for each participant in the laboratory. Participants first completed the Positive and Negative Affective

Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Then, in a separate room, they performed a classical Simon task: 1 training block and 4 experimental blocks were recorded (96 trials/block).

2.2.2. Belief manipulation

Participants were then randomly assigned to two different groups. The no-free-will group read a text claiming that scientists now recognize that free will is an illusion, while control group read a passage from the same book – i.e. the French version of *The Astonishing Hypothesis*, by Francis Crick (1994) – that did not mention free will (Rigoni et al., 2011; Vohs & Schooler, 2008). Participants were encouraged to read the text carefully and that a comprehension test would have been administered at the end of the experiment.

2.2.3. Post-manipulation session

After reading the text, each group performed 4 additional blocks of the Simon task. After the last block of the Simon task, the PANAS, and the FAD-Plus were followed-up. The duration of the entire session was about 1 h and 15 min.

3. Results

Concerning the Simon task, reaction times (RTs) faster than 100 ms (anticipations) and later than 1 s (omissions) were not considered in the analysis (i.e. less than 0.003% of all trials). Data from 2 participants in the no-free will group were rejected because of the very low accuracy in the baseline Simon task – i.e. more than 2.5 standard deviations (SDs) lower than whole sample average. Two control participants were therefore randomly selected (the only constraint was that the two group averages were eventually comparable regarding baseline task accuracy) and excluded from the analysis. This was done to assure that the two groups did not differ with respect to task performance in the baseline section, as well as with respect to the sample size. After rejection, each group included 20 participants. The two groups did not show significant differences regarding age (21.7 years-old ± 2.2 vs. 20.8 years-old ± 2.6, for control and no-free will group, respectively) and education level (14.5 years ± 1.3 vs. 14.3 years ± 0.8; all $p_s > .1$).

3.1. Belief in intentional control

Scores on the Scientific Determinism (7 items) and on the Fatalistic Determinism (5 items) subscales were inversed and aggregated to the score on the Free Will subscale (7 items) in order to obtain a positive score of belief in intentional control – i.e. Free Will score + (35 – Scientific Determinism score) + (25 – Fatalistic Determinism score). We tested whether the manipulation changed participants' belief in intentional control by entering the aggregated score as dependent variable into an ANOVA with *session* (baseline, post-manipulation) as within subjects factor and *group* (no-free will, controls) as between subjects factor. The analysis revealed a main effect of *session* ($F(1,38) = 4.65$, $p = .037$, $\eta_p^2 = .11$), indicating a reduced belief in intentional control after the manipulation (52.7 ± 8.6 vs. 50.62 ± 8.4). Although the *session* × *group* interaction did not reach significance ($F(1,38) = 2.04$, $p = .16$), specific comparisons showed that the reduction of the belief in intentional control was driven by the no-free will group (53.15 ± 8.78 vs. 49.7 ± 7.33, $t(19) = 2.61$, $p = .017$), while it was not significant in the control group (52.25 ± 8.61 vs. 51.55 ± 9.45, $t(19) = .5$, $p = .62$). Since the two groups did not differ in the baseline scores ($t(38) = -.33$, $p = .75$) this finding suggests that the manipulation reduced the belief in intentional control mainly in the no-free will group.

3.2. Post-error slowing in the Simon task

In the baseline session, mean RTs and error rates did not differ between the two groups, neither for the congruent trials (379.04 ms ± 41.69 vs. 381.32 ms ± 42.67; 96.22% ± 3.2 vs. 95.83% ± 3.27, all $p_s > .1$, for the no-free will group and the control group, respectively) nor for the incongruent trials (407.65 ms ± 43.4 vs. 406.44 ms ± 36.58; 91.83% ± 4.4 vs. 93.44% ± 6.87, all $p_s > .1$). RTs and error rates were then submitted to ANOVA with *session* and *previous trial* (correct, error) as within subjects factors, and *group* as between subjects factors. For RTs, the analysis revealed a main effect of the *previous trial* ($F(1,38) = 34.83$, $p < .0001$, $\eta_p^2 = .48$), with slower RTs after errors than after correct trials (412.08 ms ± 54.07 vs. 381.85 ms ± 38.99, respectively). Importantly we found a significant *session* × *previous trial* × *group* interaction ($F(1,38) = 5$, $p < .05$, $\eta_p^2 = .12$), with reduced post-error slowing after the belief manipulation in the no-free will group (36.99 ms ± 28.09 vs. 21.75 ms ± 29.92), but not in the control group (27.42 ms ± 43.65 vs. 34.78 ms ± 40.39) (Fig. 1). Paired comparisons indicated that post-error slowing effect changed across session for the no-free will group ($t(19) = 3.45$, $p < .01$) but not for the control group ($t(19) = -.81$, $p > .1$). We found neither main effects nor interactions with error rates as dependent variable (all $p_s > .1$).

A correlation analysis was performed to test the hypothesis that the reduction of the post-error slowing effect was related to the change of the belief in intentional

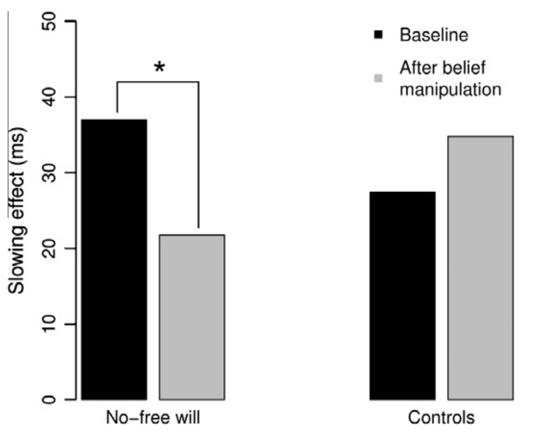

Fig. 1. Post-error slowing effect in the baseline and in the post-manipulation session, for the no-free will group (*$p < .05$) and the control group.

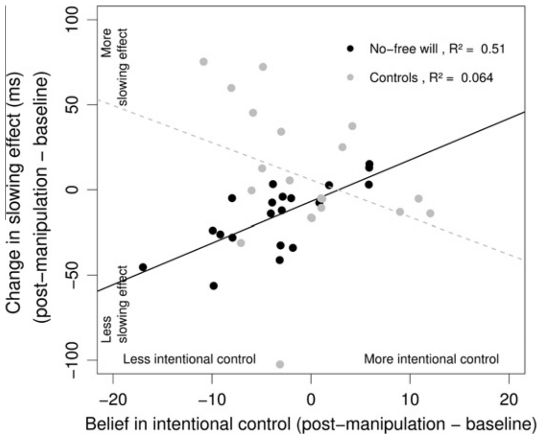

Fig. 2. The scatter plot displays the correlation between the change in the belief in intentional control score and the change in the post-error slowing effect, for both groups. The black solid line and the grey dashed line represent the regression lines for the no-free will group and the control group, respectively.

control in the no-free will group. A strong correlation was found in the no-free will group ($r = .73$, $n = 20$, $p < .0001$), but not in the control group ($r = -.33$, $n = 20$, $p = .15$) (Fig. 2). This finding indicates that the decrease of the post-error slowing in the no-free will group was more pronounced in participants showing diminished belief in intentional control after the belief manipulation. Interestingly, the slowing effect in the baseline session did not correlate with the baseline belief in intentional control ($r = -.056$, $n = 40$, $p = .73$), indicating that the behavioral effect is related to the change in the belief in intentional control – i.e. as a consequence of the belief manipulation, rather than to the *a priori* belief itself.

3.3. Ancillary measures

We wanted to exclude that other processes unrelated to the belief in intentional control were affected by the belief manipulation. For instance, the behavioral effects might be driven by a change in the emotional arousal triggered by reading the text. The PANAS scores were submitted to ANOVA with *session* as a within subjects factor, and *group* as between subjects factor. Overall, participants reported less unpleasant emotions in the post-manipulation session, as revealed by reduced PANAS negative subscale scores (17.58 ± 6.55 vs. 14.98 ± 5.35, $F(1,38) = 19.31$, $p < .0001$, $\eta_p^2 = .34$). However, the *session* × *group* interaction was not significant ($F(1,38) = 1.83$, $p = .18$). The analysis on the PANAS positive subscale scores yielded neither main effect of *session* ($F(1,38) = .29$, $p = .59$) nor *session* × *group* interaction ($F(1,38) = .61$, $p = .44$).

4. Discussion

In the current study we showed that weakening belief in intentional control impaired cognitive reaction to errors in a conflict-task: the post-error slowing, a cognitive marker of performance adjustment following errors (Laming, 1968), was reduced in the no-free-will group after exposure to a deterministic anti-free will message, as compared to the control group (Fig. 1). Furthermore, in the no-free will group the decrease of the post-error slowing was proportional to the decrease of the belief in intentional control (Fig. 2). This finding indicates that weakening the belief in intentional control impacts performance monitoring, and more specifically error monitoring processes.

The finding that the overall Simon effect (RTs and errors) did not differ in the two groups after the belief manipulation (see supplementary material) excludes the possibility that the belief manipulation decreased the overall performance in the no-free will group. In addition, no differences were found concerning other markers of performance monitoring, such as the Gratton effect (Gratton, Coles, & Donchin, 1992), suppression processes, as revealed by the analysis of delta plots (Ridderinkhof, van den Wildenberg, Wijnen, and Burle, 2004), and automatic response capture, as indicated by the conditional accuracy functions (Gratton, Coles, Sirevaag, Eriksen, & Donchin, 1988). This indicates that the belief manipulation specifically affected cognitive reaction to errors. However we also observed that, only in the no-free will group, increased intra-individual RT variability after the belief manipulation was associated with a decrease of the belief in intentional control (see supplementary material). This observation suggests that other processes reflecting performance control may have been affected by the belief manipulation (see Fiske & Rice, 1955 for an overview on performance variability).

Previous studies in social psychology have revealed that weakening the belief that people can intentionally control their own actions strongly impacts behavior (e.g., 1989; Ajzen 2002; Bandura, 1982). Namely, the stronger people's belief in their capabilities, the stronger and more persistent are the effort they put into behavior (Bandura, 1989). Recently it has been also shown that a disbelief in free will leads to antisocial tendencies, such as aggressive behavior (Baumeister et al., 2009) and cheating (Vohs & Schooler, 2008). We have argued that these effects on behavior are mediated by a degradation of basic neurocognitive processes underlying voluntary action, such as action preparation (Rigoni et al., 2011), intentional inhibition and perceived self-control (Rigoni et al., 2012). The current study extends these findings by showing that weakening belief in intentional control also impairs cognitive reaction to errors.

How does weakening the belief in intentional control leads to such behavioral and neurocognitive changes? Our results indicate that behavioral effects result from diminished belief in intentional control – i.e. as a consequence to the exposure to messages that challenge free will, – rather than the initial belief itself. In addition, the analysis on the PANAS scores suggests that the effects are not driven by the affective valence of the text. This is in line with previous data (Vohs & Schooler, 2008) that showed that mood is not crucially involved in the behavioral changes after the anti-free will manipulation. One tentative interpretation is that exposure to explicit information challenging the role of free will in goal-directed behavior, would reduce the effort for implementing cognitive control (Ridderinkhof, Ullsperger, Crone, and Nieuwenhuis, 2004). In other words, participants exposed to an anti-free will message would spend less effort to adjust their performance according to contextual needs. Under this perspective, a decrease of post-error slowing in the no-free will group may reflect a reduced recruitment of cognitive control processes involved in action monitoring. An account involving diminished intentional effort for exerting cognitive control would be in line with prior observations of reduced intentional inhibition and perceived control (Rigoni et al., 2012), and reduced neurophysiological correlates of intentional action preparation (Rigoni et al., 2011), after exposure to information denying free will. Also, it may explain why weakening belief in free will leads to antisocial tendencies. A lack of cognitive control would likely result in more carless and impulsive behavior, and this in turn may lead people to display antisocial tendencies (Baumeister et al., 2009; Vohs & Schooler, 2008).

In sum, our results indicate that weakening belief in intentional control can affect the way people react to errors in order to adjust their performance. This observation suggests that challenging the role of intentional control may lead people to be less concerned about the negative consequences of their actions. We propose that disproving intentional control by exposing participants to a message that denies free will results in reduced effort to implement cognitive control. A decreased intentional effort to exert cognitive control may be the candidate basic process accounting for the observation that reducing belief in free will leads to antisocial behavior.

Acknowledgements

This research was supported by the European Research Council under the European Community's Seventh Framework Program (FP7/2007-2013 Grant Agreement n. 241077). We wish to thank Maurits van der Molen and Matthew Dyson for the clever suggestions for interpreting the data, and Jonathan Schooler, Roy Baumeister, and Andy Vonash for their useful comments on a preliminary version of the manuscript.

References

Ajzen, I. (2002). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology, 32*, 665–683.

Alain, C., McNeely, H. E., He, Y., Christensen, B. K., & West, R. (2002). Neurophysiological evidence of error-monitoring deficits in patients with schizophrenia. *Cerebral Cortex, 12*, 840–846.

Bandura, A. (1982). Self-efficacy in human agency. *American Psychologist, 37*, 122–147.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*, 1175–1184.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*(5), 1252–1265.

Baumeister, R. F., Crescioni, A. W., & Alquist, J. L. (2011). Free will as advanced action control for human social life and culture. *Neuroethics, 4*(1), 1–11.

Baumeister, R. F., Masicampo, E. J., & DeWall, C. N. (2009). Prosocial benefits of feeling free: Disbelief in free will increases aggression and reduces helpfulness. *Personality and Social Psychology Bulletin, 35*, 260–268.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624–652.

Carter, C. S., MacDonald, A. W., Ross, L. L., & Stenger, V. A. (2001). Anterior cingulate cortex activity and impaired self-monitoring of performance in patients with schizophrenia: An event-related fMRI study. *American Journal of Psychiatry, 158*, 1423–1428.

Crick, F. (1994). The astonishing hypothesis. The scientific search for the soul. New York: Charles Scribner's Sons, Macmillan Publishing Company. (For the French version: L'hypothèse stupefiante. Paris: Librairie Plon).

Fiske, D. W., & Rice, L. (1955). Intra-individual response variability. *Psychological Bulletin, 52*(3), 217–250.

Fitzgerald, K. D., Welsh, R. C., Gehring, W. J., Abelson, J. L., Himle, J. A., Liberzon, I., et al. (2005). Error-related hyperactivity of the anterior cingulate cortex in obsessive–compulsive disorder. *Biological Psychiatry, 57*, 287–294.

Gailliot, M. T., & Baumeister, R. F. (2007). The physiology of willpower: Linking blood glucose to self-control. *Personality and Social Psychology Review, 11*, 303–327.

Gailliot, M. T., Baumeister, R. F., DeWall, C. D., Maner, J. K., Plant, E. A., Tice, D. M., et al. (2007). Self-control relies on glucose as a limited energy source. Willpower is more than a metaphor. *Journal of Personality and Social Psychology, 92*(2), 325–336.

Gratton, G., Coles, M. G. H., & Donchin, E. (1992). Optimizing the use of information: Strategic control of activation of responses. *Journal of Experimental Psychology: General, 4*, 480–506.

Gratton, G., Coles, M. G., Sirevaag, E. J., Eriksen, C. W., & Donchin, E. (1988). Pre- and poststimulus activation of response channels: A psychophysiological analysis. *Journal of Experimental Psychology: Human Perception and Performance, 14*, 331–344.

Hajcak, G., & Simons, R. F. (2002). Error-related brain activity in obsessive-compulsive undergraduates. *Psychiatry Research, 110*(1), 63–72.

Jonkman, L. M., van Melis, J. J. M., Kemner, C., & Markus, C. R. (2007). Methylphenidate improves deficient error evaluation in children with ADHD: An event-related brain potential study. *Biological Psychology, 76*(3), 217–229.

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R. Y., Stenger, V. A., & Carter, C. S. (2004). Anterior cingulate conflict monitoring and adjustments in control. *Science, 303*, 1023–1026.

Kerns, J. G., Cohen, J. D., MacDonald, A. W. I., Johnson, M. K., Stenger, V. A., Aizenstein, H., et al. (2005). Decreased conflict – And error-related activity in the anterior cingulate cortex in subjects with schizophrenia. *American Journal of Psychiatry, 162*, 1833–1839.

Laming, D. R. (1968). *Information theory of choice-reaction times*. London: Academic Press.

Leotti, L., Iyengar, S. S., & Ochsner, K. N. (2010). Born to choose: The origins and value of the need for control. *Trends in Cognitive Sciences, 14*(10), 457–463.

Notebaert, W., Houtman, F., Opstal, F. V., Gevers, W., Fias, W., & Verguts, T. (2009). Post-error slowing: An orienting account. *Cognition, 111*, 275–279.

Paulhus, D. L., & Carey, J. M. (2011). The FAD-Plus: Measuring lay beliefs regarding free will and related constructs. *Journal of Personality Assessment, 93*(1), 96–104.

Rabbitt, P. M. (1966). Errors and error correction in choice-response tasks. *Journal of Experimental Psychology, 71*(2), 264–272.

Ridderinkhof, K. R., Ullsperger, M., Crone, E. A., & Nieuwenhuis, S. (2004). The role of the medial frontal cortex in cognitive control. *Science, 306*, 443–447.

Ridderinkhof, K. R., van den Wildenberg, W. P. M., Segalowitz, S. J., & Carter, C. S. (2004). Neurocognitive mechanisms of cognitive control: The role of prefrontal cortex in action selection, response inhibition, performance monitoring, and reward-based learning. *Brain and Cognition, 56*, 129–140.

Ridderinkhof, K. R., van den Wildenberg, W. P. M., Wijnen, J., & Burle, B. (2004). Response inhibition in conflict tasks is revealed in delta plots. In M. I. Posner (Ed.), *Cognitive neuroscience of attention* (pp. 369–377). New York: Guilford.

Rigoni, D., Kühn, S., Gaudino, G., Sartori, G., & Brass, M. (2012). Reducing self-control by weakening belief in free will. *Consciousness and Cognition, 21*(3), 1482–1490.

Rigoni, D., Kühn, S., Sartori, G., & Brass, M. (2011). Inducing disbelief in free will alters brain correlates of preconscious motor preparation: The brain minds whether we believe in free will or not. *Psychological Science, 22*(5), 613–618.

Schachar, R. J., Chen, S., Logan, G. D., Ornstein, T. J., Crosbie, J., Ickowicz, A., et al. (2004). Evidence for an error monitoring deficit in attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology, 32*, 285–293.

Sergeant, J. A., & van der Meere, J. (1988). What happens after a hyperactive child commits an error? *Psychiatry Research, 24*, 157–164.

Simon, J. R. (1990). The effects of an irrelevant directional cue on human information processing. In R. W. Proctor & T. G. Reeve (Eds.), *Stimulus–response compatibility: An integrated perspective* (pp. 31–86). Amsterdam: North-Holland.

Vohs, K. D., & Schooler, J. W. (2008). The value of believing in free will: Encouraging a belief in determinism increases cheating. *Psychological. Science, I, 19*, 49–54.

Watson, D., Clark, L. E., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.

Wiersema, J. R., van der Meere, J. J., & Roeyers, H. (2005). ERP correlates of impaired error monitoring in children with ADHD. *Journal of Neural Transmission, 112*(10), 1417–1430.