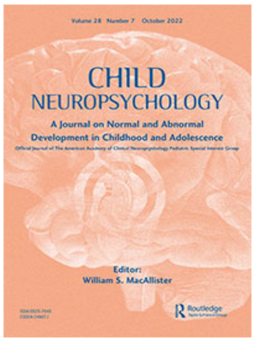

Child Neuropsychology

A Journal on Normal and Abnormal Development in Childhood and Adolescence

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ncny20

Dissociable effects of positive feedback on the capture and inhibition of impulsive behavior in adolescents with ADHD versus typically developing adolescents

Aurélie Grandjean, Isabel Suarez, David Da Fonseca & Laurence Casini

To cite this article: Aurélie Grandjean, Isabel Suarez, David Da Fonseca & Laurence Casini (2022): Dissociable effects of positive feedback on the capture and inhibition of impulsive behavior in adolescents with ADHD versus typically developing adolescents, Child Neuropsychology, DOI: 10.1080/09297049.2022.2100882

To link to this article: https://doi.org/10.1080/09297049.2022.2100882

CHILD NEUROPSYCHOLOGY
https://doi.org/10.1080/09297049.2022.2100882

Routledge
Taylor & Francis Group

Check for updates

Dissociable effects of positive feedback on the capture and inhibition of impulsive behavior in adolescents with ADHD versus typically developing adolescents

Aurélie Grandjean [a], Isabel Suarez [b], David Da Fonseca [c] and Laurence Casini [a]

[a]Laboratoire de Neurosciences Cognitives, Aix-Marseille Université, CNRS, Marseille, France; [b]Departamento de Psicología, Universidad del Norte, Baranquilla, Colombia; [c]Service de psychiatrie infanto-juvénile, Hôpital Salvator, Marseille, France

ABSTRACT

The present study investigated how enhancing motivation by delivering positive feedback (a smiley) after a successful trial could affect interference control in adolescents with Attention Deficit Hyperactivity Disorder (ADHD) and in their typically developing (TD) peers. By using a Simon task within the theoretical framework of the “activation-suppression” model, we were able to separately investigate the expression and the inhibition of impulsive motor behavior. The experiment included 19 adolescents with ADHD and 20 TD adolescents in order to explore whether data found in adolescents with ADHD were similar to those found in TD adolescents. Participants performed the Simon task in two conditions: a condition with feedback delivered after each successful trial and a condition with no feedback. The main findings were that increasing motivation by delivering positive feedback increased impulsive response in both groups of adolescents. It also improved the efficiency of impulsive motor action inhibition in adolescents with ADHD but deteriorated it in TD adolescents. We suggest that 1/ increased motivation could lead adolescents to favor fast responses even if incorrect, and 2/the differential effect of feedback on the selective suppression of impulsive motor action in both groups could be due to different baseline DA levels.

ARTICLE HISTORY
Received 20 June 2021
Accepted 7 July 2022

KEYWORDS
ADHD; motivation; interference control; Simon task; distributional analysis

Diagnosed in about 5% of the population (Polanczyk et al., 2007), attention deficit hyperactivity disorder (ADHD) is the most frequently diagnosed neurodevelopmental disorder in childhood. Manifesting itself mainly in symptoms of inattention, impulsivity, and hyperactivity (American Psychiatric Association [APA], 2000), it leads to severe impairments across cognitive, behavioral and interpersonal domains leading to great difficulty in academic learning, and social, and familial relationships.

Various neurocognitive deficits have also been reported in children and adolescents with ADHD. Among them, cognitive control seems particularly impaired in these children and adolescents, who very often exhibit deficits in tasks requiring interference control (Cao et al., 2013; Homack & Riccio, 2004; Jonkman et al., 1999; for a review, see

CONTACT Aurélie Grandjean laurence.casini@univ-amu.fr LNC FR 3C, Case C, 3 place Victor Hugo, Marseille cedex 3 13331, France

Mullane et al., 2009; Tsal et al., 2005). Interference control is required each time there is a conflict between an automatic but inappropriate response and a goal-directed response. This is particularly well-illustrated by so-called conflict tasks, such as the Simon task (Simon, 1969), the flanker task (Eriksen & Eriksen, 1974) or the Stroop task (Stroop, 1935), in which the processing of irrelevant information in a visual display activates a prepotent response that directly conflicts with the response required by task rules.

The resolution of conflict in this type of task involves cognitive control networks engaging prefrontal and motor areas of the frontal cortex in tandem with the basal ganglia (for review, see Aron, 2007; Aron et al., 2016; Botvinick et al., 2001; Carter et al., 2000; Casey et al., 2000; Chambers et al., 2009; Fassbender and Schweitzer, 2006; Forstmann et al., 2008; Ridderinkhof, Ullsperger, et al., 2004; Ridderinkhof, van den Wildenberg, Segalowitz et al., 2004; Ridderinkhof et al., 2011; Stürmer, 2007). Most of these structures have also been reported as being dysfunctional in individuals with ADHD (Dickstein et al., 2006; Emond et al., 2009; Hart et al., 2013; Konrad & Eickhoff, 2010; Vaidya et al., 2005) which could explain why they have difficulty performing conflict tasks. Moreover, some of these structures, such as the basal ganglia (Chambers et al., 2009), the anterior cingulate cortex (ACC; Holroyd & Yeung, 2012; Kouneiher et al., 2009) and the dorsolateral prefrontal cortex (DLPFC; Spielberg et al., 2012) are also involved in reinforcement learning and reward expectation, that is in the motivation system. This suggests that motivation and cognitive control could be linked and, therefore, that deficits in children and adolescents with ADHD could also be explained by motivational dysfunction. This hypothesis is consistent with one influential explicative model of ADHD, the dual-pathway model (Sonuga-Barke, 2002, 2003). This model proposes that dysfunction in two different neurobiological pathways can lead to ADHD: an executive dysfunction pathway linked to deficits in interference control, and a motivational dysfunction pathway linked to suboptimal reinforcement processes, with the motivational pathway affecting the cognitive control pathway.

It is therefore relevant to determine whether reinforcing their motivation could enhance interference control in young adolescents with ADHD. Numerous studies have already revealed that reinforcement-enhanced cognitive performance in children and adolescents with ADHD (for review, see Luman, Oosterlaan, et al., 2005; Luman, Tripp, et al., 2010). For example, it has been shown that reinforcement enhanced sustained attention (Bubnik et al., 2015) and working-memory (Strand et al., 2012). In both studies, performance was more largely improved by reinforcement in children with ADHD than in typically developing peers. Reinforced motivation has also been shown to improve inhibitory processes (Oosterlaan & Sergeant, 1998; Slusarek et al., 2001), often considered as impaired in ADHD. Indeed, reinforcement helped to normalize response inhibition in children with ADHD in stop-signal tasks (Konrad et al., 2000; Rosch et al., 2016; Scheres et al., 2001) as well as in go-no go tasks (Demurie et al., 2016; Groom et al., 2010). In literature about the impact of reinforcement on interference control, it has been reported that social motivation (Geurts et al., 2008) or monetary reward (Rosch & Hawk, 2013) improved accuracy rate and response speed in children with ADHD performing a flanker task. But more recently, in a Stroop task, children with ADHD showed better accuracy and response speed in rewarding trials although the interference effect due to conflict between automatic and controlled responses was not improved (Ma et al., 2016).

The processing of information therefore seems to be globally improved by increased motivation but whether and how motivation can also improve interference control abilities in children and adolescents with ADHD remains unclear.

The present study thus aimed to investigate whether increasing motivation could improve interference control in adolescents with ADHD. Interference control was investigated with a Simon task and motivation level was manipulated by providing positive feedback after each successful trial. We compared performance of adolescents with ADHD in two different conditions: when they performed a Simon task without positive feedback (NO FB condition) *versus* with positive feedback (FB condition). Based on the dual-pathway model (Sonuga-Barke, 2002, 2003), we hypothesized an improvement in interference control when adolescents with ADHD performed the Simon task in the FB condition. To determine whether or not results found in adolescents with ADHD were specific to this population, the experiment was also simultaneously carried out in typically developing (TD) adolescents.

The Simon task and the "Activation-suppression" model

In the classic version of the Simon task, participants have to choose between a right or left response depending on the color (or shape) of a visual stimulus presented either to the right or left of a central fixation point. Although stimulus position is irrelevant for the task, performance, expressed in terms of mean reaction time (RT) and accuracy, is better when the required response spatially corresponds to the stimulus location (congruent trials, CG) than when it does not (incongruent trials, IG). This pattern is called the "Simon effect" or "interference effect" (Hedge & Marsh, 1975; Hommel, 2011; Simon, 1990).

A widely accepted interpretation of the interference effect is that stimulus position automatically activates the response ipsilateral to the stimulus by a fast and direct pathway, whereas stimulus color activates the required response by a slow and controlled pathway (Kornblum et al., 1990). Thus, in CG trials, both stimulus position and color activate the same response, facilitating its execution. By contrast, in IG trials, each attribute activates a different pathway, leading to competition between both responses. This competition is thought to be at the origin of the performance impairment, leading to slower reaction time and more errors. The magnitude of interference effects in conflict tasks has been widely used to study condition or group differences in interference control. But a more elaborate conceptual framework for studying interference control is provided by the "activation-suppression" model (Ridderinkhof, 2002; van den Wildenberg et al., 2010). This model uses dynamic analyses of performance to dissociate two temporally and functionally distinct processes of interference control. The first is activation of the initial prepotent response ipsilateral to the stimulus, that we will call response capture or impulse capture. The strength of impulse capture is reflected in the proportion of fast impulsive errors, which can be observed by plotting accuracy rates against RT in IG trials (conditional accuracy function) (Figure 1(a); Kornblum et al., 1990; van den Wildenberg et al., 2010; Wylie et al., 2010). The second is the inhibitory control that is needed to selectively suppress impulse capture. To suppress the interference induced by an incorrect response activation, this inhibitory process is thought to be engaged more slowly and to build up gradually over time (Ridderinkhof, 2002).

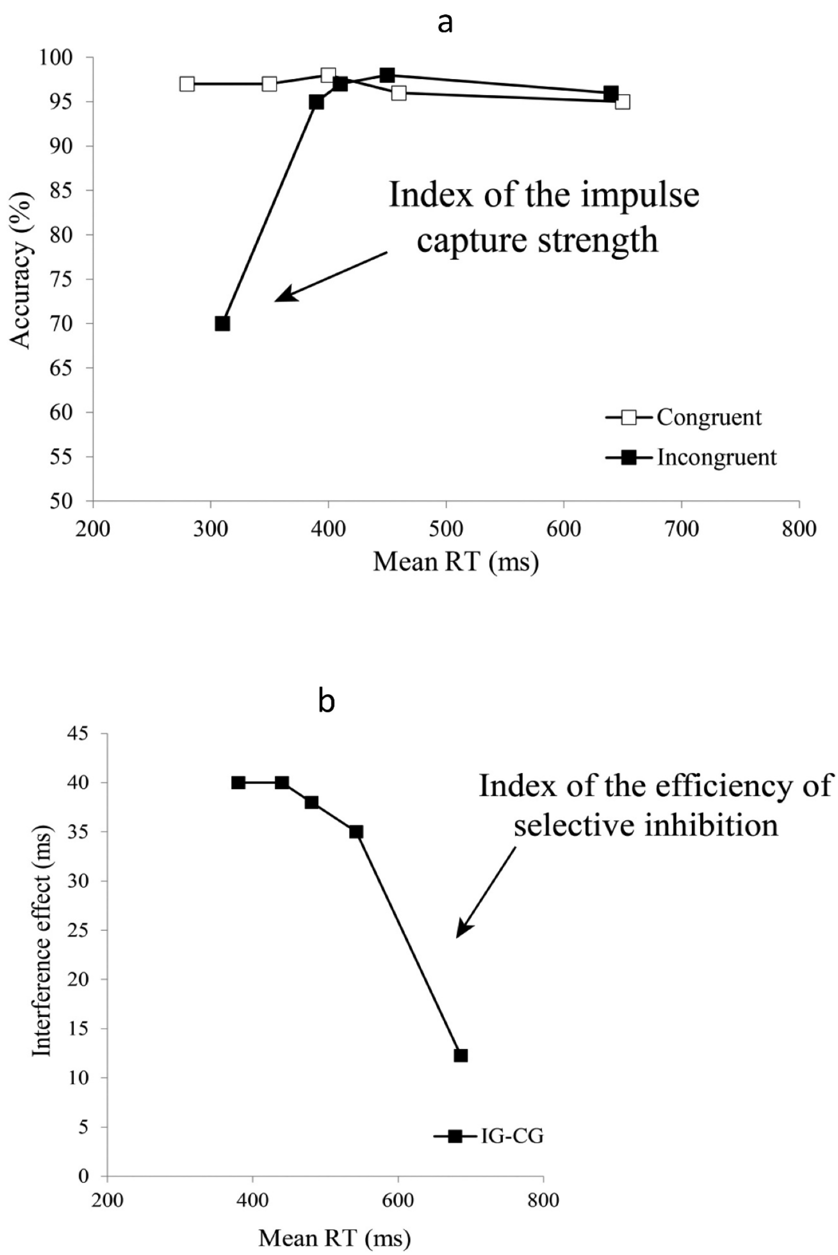

Figure 1. Example of a distributional analysis of performancewith five quantiles. (a) Conditional accuracy functions (CAF) for congruent (white squares) and incongruent (black squares) trials. (b) Delta plot representing the interference effect as a function of the response speed.

Therefore, the efficiency of inhibitory control should be most evident at the slow end of the RT distribution, and can be observed when plotting the magnitude of the interference effect (Simon effect) as a function of response speed (delta-plot) (Figure 1(b); Proctor, 2011; Ridderinkhof, 2002). According to the activation-suppression model, the magnitude of the interference effect at the slowest point of the delta-plot provides a very sensitive index of the efficiency of selective suppression of incorrect action impulses (van den Wildenberg et al., 2010). This method of dissociating these two complementary processes of interference control had received empirical support from several studies in healthy populations (Burle et al., 2002, 2005; van den Wildenberg et al., 2010; Wijnen & Ridderinkhof, 2007), as well as in clinical populations such as children with ADHD (Grandjean, Suarez, Diaz, et al., 2021; Grandjean, Suarez, Miquee, et al., 2021; Ridderinkhof et al., 2005), adults with ADHD (Suarez, Burle, et al., 2015a); Parkinson's Disease patients (Fluchère et al., 2015; van Wouwe et al., 2016; Wylie et al., 2010, 2012), and Tourette Syndrome patients (Wylie et al., 2013). Moreover, it has been shown that these two components of interference control can be differently impacted in certain cases (Fluchère et al., 2015, 2018; Grandjean, Suarez, Miquee, et al., 2021; Ramdani et al., 2015). Some authors have also suggested that these functions are probably associated with different brain systems by quantifying the extent to which RT distribution measures of response inhibition were associated with individual differences in different brain areas activity (Forstmann et al., 2008). Therefore, it seems of importance to have analytical tools allowing the two processes to be dissociated when investigating cognitive processes underlying cognitive control (for more information about validity tests for these tools, see Ridderinkhof, 2002; van den Wildenberg et al., 2010).

To summarize, the aim of the present study was to investigate whether increasing motivation by providing positive feedback will improve interference control in adolescents with ADHD. Moreover, by using dynamic analysis of performance, we can dissociate putative effects on both the expression and the inhibition of impulse capture that allows for deeper understanding of both ADHD pathophysiology and the links between motivation and cognitive control.

Material and methods

Participants

Nineteen adolescents with ADHD (aged 11–16; mean = 13.6; 17 males) and 20 TD adolescents (aged 11–15; mean = 13.6; 18 males) participated in this study. Demographic data are presented in Table 1. All participants and their parents gave informed consent prior to the experiment.

Table 1. Demographic variables (mean and standard error of the mean, SEM). IQ = intellectual quotient; Attention symptoms and Impulsivity/Hyperactivity symptoms were assessed by using the Conner's Parent Rating scales.

	ADHD Group (n = 19; 17 males)	TD group (n = 20; 17 males)	ADHD *vs*. TD
	Mean ± SEM	Mean ± SEM	t_{37}; p value
Age (years)	13.6 ± 1.7	13.5 ± 1.3	.55; p = .71
Estimated IQ	89 ± 3.5	98 ± 6.2	.19; p = .88
Attention (T-score)	75.3 ± 6	46.2 ± 2.3	5.4; p< 0.001
Impulsivity/ /Hyperactivity (T-score)	73.6 ± 4.2	45.4 ± 2.2	6.3; p< 0.001

Selection procedure for the ADHD group

All participants were recruited from a sample of patients who had been referred in the Department of Child and Adolescent Psychiatry (Salvator Hospital, Marseille, France) by a pediatrician or psychiatrist and who are regularly followed for ADHD by psychiatrists in the Department. All diagnostics were made by a psychiatrist of the Department specialized in ADHD. The assessment was made on the basis of a semi-structured clinical diagnostic interview (Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version; K-SADS-PL) conducted separately with parents and one referent teacher by trained child and adolescent psychiatrists specialized in ADHD. The K-SADS-PL has been extensively used to make diagnostic decisions based on DSM criteria and has been previously validated in children and adolescents from 6–17 years old (Kaufman et al., 1997). In addition, parents and teachers of each adolescent also filled out behavior rating scales (the Conner's Parent and Teacher Rating scales, Conners, 1969). The full history of the adolescent's development and academic performance, an interview with parents and the adolescent, and behavioral observations served to confirm the diagnosis. All adolescents followed for ADHD in this Department met the DSM IV diagnostic criteria for ADHD (APA, 2000). For this study, in order for the ADHD group to be as homogenous as possible but also not reduced to only one symptom (impulsivity or attention), all adolescents met the criteria for the combined subtype. Finally, the following exclusion criteria were applied : (1) IQ less than 80, (2) evidence of a neurological disorder such as epilepsy, (3) associated medical disorders or comobidities, (4) history or evidence of psychosis, and (5) absence of parental consent. It should be noted that all adolescents who participated in this study had never received medication.

Criteria for the TD adolescents group

Participants from the TD group were recruited via local schools in Marseille. The adolescents were globally paired in age and education level to adolescents of ADHD group. They all attended age-appropriate classes. Exclusion criteria were as follows: 1/ presence of learning disabilities or psychiatric disease reported by parents or teachers, 2/ an IQ less than 80, 3/absence of current or prior diagnosis of ADHD determined by the completion of the Conner's Parent Rating Scale.

Apparatus and procedure

Stimuli and apparatus

Participants were comfortably seated facing a black computer screen, located 80 cm away, upon which stimuli appeared. The responses were given by pressing the A and P keys (of an Azerty keyboard) either with the left or right index finger, respectively. All stimuli and responses were controlled by the computer. RTs were recorded to the nearest millisecond.

Task and procedure

Adolescents were required to respond as quickly and as accurately as possible to stimulus color. Each trial started with the apparition of a central fixation point that participants had to fixate during the whole trial. After a delay of 400 ms, a red or a green circle appeared either on the right or left of the fixation point. Adolescents had to briefly press either the A or P key according to the red or green color of the circle and the color-response mapping given by the experimenter (press right for red and left for green, or *vice-versa*). The color-response mapping was balanced across participants. The adolescents had a delay of 2000 ms to give their response. The next trial was presented 1500 ms after the response or at the end of the delay in the absence of a response. In congruent trials (CG), the required response was ipsilateral to stimulus location and in incongruent trials (IG), the required response was contralateral to stimulus location.

Participants performed the Simon RT task in two experimental conditions, a condition without feedback (NO FB) and a condition with feedback (FB), which were presented in counterbalanced order across participants. In the FB condition, a large yellow smiley was presented at the end of the trial (and remained on the screen until the next trial onset) each time the adolescent reached the criterion for response speed and gave a correct response. The criteria for response speed was to be faster than the mean RT (averaged across CG and IG trials) obtained in a training block consisting of 32 trials (16 CG trials and 16 IG trials). Mean RT criteria were of 505 ms ($\sigma = 111$) for ADHD group and of 471 ms ($\sigma = 56$) for TD group ($t_{38} = .76$; $p = .22$). There was no feedback when the criterion for response speed was not reached or when the response was not correct. In this case, the screen remained black until the next trial, as in the NO FB condition. Therefore, in both cases, the next trial was presented 1500 ms after the response.

In the NO FB condition, feedback was never delivered at the end of the trial no matter how the adolescent had performed and then the screen remained black until the next trial presented 1500 ms after the response. For each condition, adolescents performed two blocks of 48 trials each. Within each block, there were 24 green and 24 red stimuli. For each color, there were 12 CG trials and 12 IG trials. The entire experiment lasted about 25 min.

Dynamic analysis of performance

Besides global measure of performance expressed in terms of mean RT, accuracy rate and interference effect, we performed a dynamic analysis of performance according to the activation-suppression cognitive model of interference control (see the detailed description of the methods in Ridderinkhof, 2002).

Impulse capture: dynamic analysis of accuracy

The dynamic analysis of accuracy is based on a distributional accuracy analysis. We computed the so-called "conditional accuracy function" (CAF) in IG trials: Correct and erroneous trials were mixed together and the resulting distributions were vincentized (Ratcliff, 1979; Vincent, 1912), which means that IG trial RTs were rank-ordered and binned into five quintiles of equal frequency (i.e., the same number of trials in each quintile). For each bin, the proportion of correct trials was computed along with the mean RT for that bin. These data were then averaged per bin across participants. This measure provides mean accuracy as a function of increasing RT. We used the first point of the distribution (fast errors rate) as an index of the strength of impulse capture (for more information, see Burle et al., 2002; Ridderinkhof, 2002; van den Wildenberg et al., 2010), with stronger capture reflected by a higher percentage of fast errors.

Selective response inhibition: dynamic analysis of interference effect

The dynamic analysis of the interference effect relies on distribution analyses of RTs. The cumulative density functions (CDF) of correct trials were estimated for each participant and averaged through the so-called "vincentizing" procedure (Ratcliff, 1979; Vincent, 1912): RTs were rank-ordered for each type of trial separately (CG trials and IG trials) and binned into five quintiles of equal frequency. The mean of each bin was computed and corresponding bins were averaged across participants. Delta-plots were constructed by plotting the interference effect (i.e., the difference in mean RT between IG and CG trials) for each bin, as a function of the mean IG and CG bin values (for more information, see Burle et al., 2002; Ridderinkhof, 2002; Ridderinkhof, van den Wildenberg, Wijnen, et al., 2004; van den Wildenberg et al., 2010). We used the last point of the delta-plot as an index of the efficiency of the selective suppression of incorrect impulsive action. More efficient inhibition is reflected by a larger reduction in interference, that is a smaller interference effect for the longest RTs.

Results

Extreme RT values, either too fast (<150 ms, also called anticipatory errors) or too slow (>3 standard deviations) were removed from the analysis. This accounted for fewer than 1% of trials across participants. In the first part of the results section, we present data as it is usually reported in the literature, that is overall mean reaction time (RTs) and accuracy rates. In the second part, we present indices computed from dynamic analyses of performance and in a third part, we present proportion of trials in which smiley was provided.

Overall performance

Three-way ANOVAs were performed on both mean RTs and accuracy rates with Congruency (CG *versus* IG) and Feedback (NO FB *versus* FB) as within-subject factors and Group (ADHD *versus* TD) as a between-subjects factor. Proportional scores such as accuracy rate, particularly when they are rather high (or low), have non-Gaussian distributions because of ceiling (or floor) effects. Therefore, to normalize distributions, data were arcsine transformed before being entered into the ANOVA. This nonlinear but monotonic transformation allows a Gaussian distribution to be obtained so that the required conditions for the ANOVA are met (Winer, 1970)[1]

Post-Hoc power analysis

As the size of our samples depended on the availability of children but not on a formal power analysis, we checked whether our samples were sufficiently large to detect the second-order interaction (congruency × feedback × group). According to G*Power (Faul et al., 2009), the size of the samples allowed for the detection of an effect size of 0.25 (considering as a medium effect size, Cohen, 1988), and the power for interactions was .90. Accordingly, it seems reasonable to consider that the size of our sample was sufficient to detect the interaction.

[1]For information, the transformation of data did not change the results of the ANOVA..

Mean RTs

As illustrated in Figure 2(a), both groups were faster in the FB (444 ms; σ = 83) than NO FB condition[2] (464 ms; σ = 85) (Feedback: $F_{1,37} = 9.52$, $p < .01$, $\eta_p^2 = .2$; Group: $F_{1,37} = 2.7$, $p = .11$, $\eta_p^2 = .07$; Feedback × Group : $F_{1,37} = 0.02$, $p = .88$, $\eta_p^2 < .001$) and faster in CG trials (437 ms; σ = 84) than IG trials (472 ms; σ = 86; Congruency : $F_{1,37} = 91.78$, $p < .0001$, $\eta_p^2 = .71$; Congruency × Group : $F_{1,37} = .01$, $p = .92$, $\eta_p^2 < .001$). The difference in mean RT between CG and IG trials, corresponding to the interference effect, did not vary as a function of feedback condition, as confirmed by the non-significant Feedback × Congruency interaction ($F_{1,37} = 1.37$; $p = .24$, $\eta_p^2 = .03$). The Feedback × Congruency × Group interaction was only marginally significant ($F_{1,37} = 2.96$; $p = .09$, $\eta_p^2 = .07$) but the Feedback × Congruency interaction was not significant, neither in ADHD group ($F_{1,18} = 2.9$; $p = .11$, $\eta_p^2 = .14$), nor in TD group ($F_{1,19} = 0.25$; $p = .62$, $\eta_p^2 = .01$).

Accuracy rates

As illustrated in Figure 2(b), in both groups, the accuracy rate was lower in the FB[3] (91.8%; σ = 5.7) than NO FB condition (94.6%; σ = 4.2) (Feedback : $F_{1,37} = 13.28$; $p < .01$, $\eta_p^2 = .26$; Group : $F_{1,37} = 1.21$; $p = .28$, $\eta_p^2 = .03$; Feedback × Group interaction: $F_{1,37} = 0.13$; $p = 0.7$, $\eta_p^2 = .003$), and in IG trials (91%; σ = 7.24) than CG trials (95.4%; σ = 5.33; Congruency: $F_{1,37} = 23.9$; $p < .001$, $\eta_p^2 = .39$). The Feedback × Congruency interaction was marginally significant ($F_{1,37} = 3.25$; $p = .08$, $\eta_p^2 = .8$) and the Feedback × Congruency × Group interaction was not significant ($F_{1,37} = 2.39$; $p = 13$, $\eta_p^2 = .06$).

Dynamic analysis of the performance

Concerning the strength of impulse capture, a three-way ANOVA with Feedback (NO FB *versus* FB) and Quintile as within-subject factors and Group (ADHD *versus* TD) as a between-subjects factor was performed on accuracy rates for the IG CAF. A two-way ANOVA with Feedback (NO FB *versus* FB) as a within-subject factor and Group (ADHD *versus* TD) as a between-subjects factor was performed on the first quintile value of the IG CAF to compare the strength of impulse capture between feedback conditions and groups. Concerning the efficiency of selective inhibition, we first ran a 4-way ANOVA on mean RTs with Congruency (CG *versus* IG), Feedback (NO FB *versus* FB) and Quintiles as within-subjects factors and Group (ADHD versus TD) as a between-subjects factor then two three-ways ANOVA were separately performed for each group of participants. Finally, when needed, *t* tests were performed to compare the value of the last quintile of the delta-plots.

[2]We first ran an ANOVA adding Order as a within-subject factor. There was no significant main effect of Order and the only significant interaction involving Order was the Order × Feedback interaction ($F_{1,35} = 32.49$; $p < .001$): The effect of feedback was significant when participants performed the NO FB condition first ($t_{19} = 6.63$; $p < .001$) but not when they performed the FB condition first ($t_{18} = 0.92$; $p = .18$). It is likely due to the persistence of feedback effect. For sake of clarity, we did not report data of the ANOVA including factor Order.

[3]We first ran an ANOVA adding Order as a within-subject factor. There was no significant main effect of Order and the only significant interaction involving Order was the Order × Feedback interaction ($F_{1,35} = 9.06$; $p < .01$) : The effect of feedback was significant when participants performed the NO FB condition first ($t_{19} = 4.25$; $p < .01$) but not when they performed the FB condition first ($t_{18} = 0.40$; $p = .65$). It is likely due to the persistence of feedback effect. For sake of clarity, we did not report data of the ANOVA including factor Order.

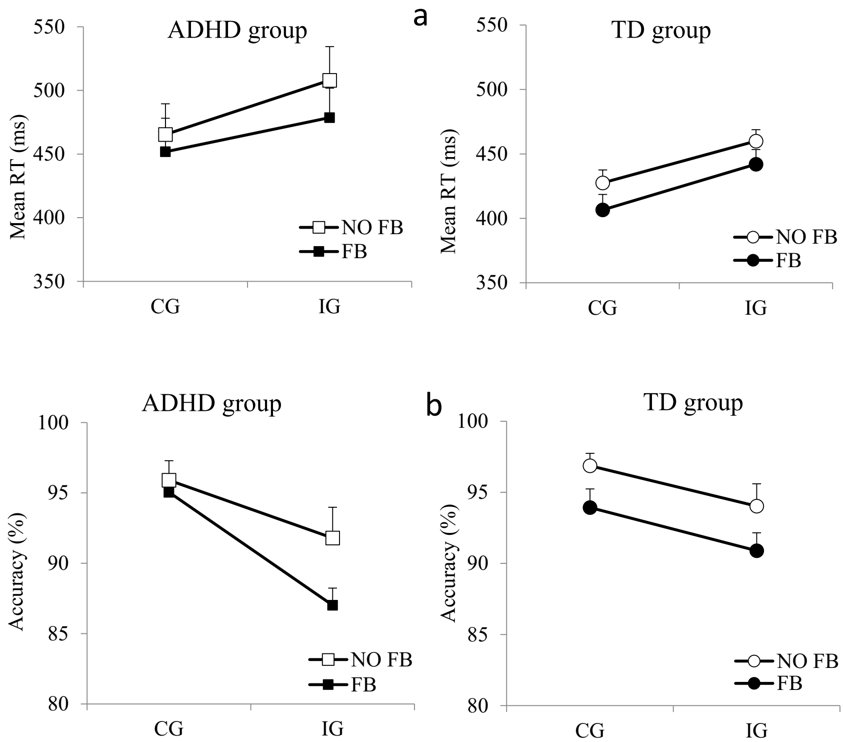

Figure 2. Simon task performance. Mean reaction time (a) and accuracy rates (b) in two experimental conditions, without feedback (NO FB) and with feedbacks (FB). Error bars are mean standard errors.

Impulse capture

As is usually observed, both groups of participants committed more errors at the shortest RTs[4] (Quintile: $F_{4,148} = 37.65$; $p < .0001$, $\eta_p^2 = .5$) for both conditions of feedback (Feedback × Quintile × Group: $F_{4,\ 148} = 0.28$; $p = .88$, $\eta_p^2 = .008$) (Figure 3). More relevant for our purposes, the comparison of the first quintile value revealed that participants of both groups committed more fast errors in the FB condition than the NO FB condition ($F_{1,37} = 10.79$; $p < .01$, $\eta_p^2 = .22$; Feedback × Group interaction: $F_{1,37} = .005$; $p = .9$, $\eta_p^2 < .001$). This suggests that feedback increased the strength of impulse capture in both groups of adolescents[5]

Selective inhibition

The Feedback × Congruency × Quintile × Group interaction ($F_{4,148} = 8.49$; $p < .001$, $\eta_p^2 = .18$) indicates that the difference in delta-plots between both feedback conditions was different between groups. The Feedback × Congruency × Quintile interaction was significant in both groups (ADHD group: $F_{4,72} = 2.92$; $p < .05$, $\eta_p^2 = .14$; TD

[4]This effect was found in 80% of adolescents with ADHD.
[5]There was no effect of Order on the index of impulse capture..

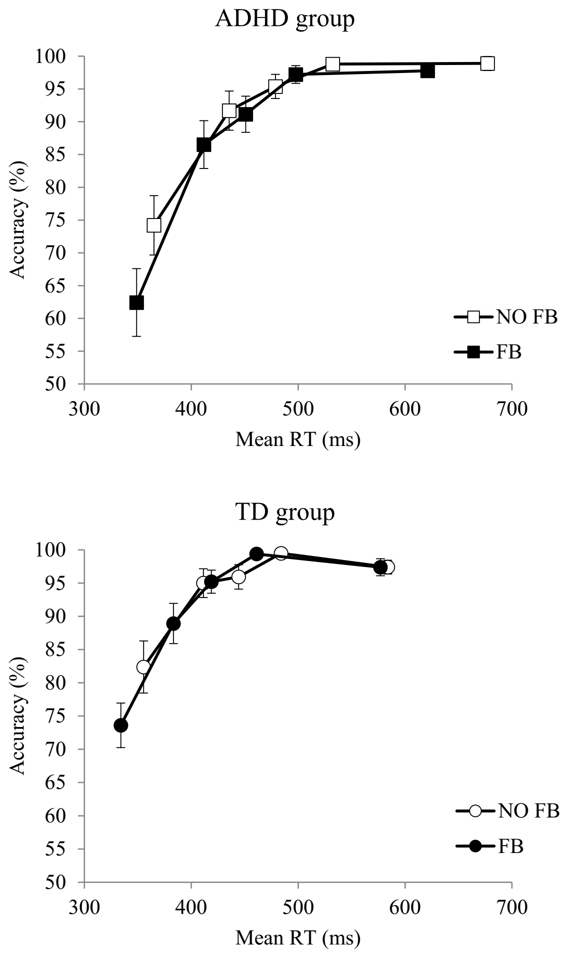

Figure 3. Distributional analysis of accuracy. Conditional accuracy functions (CAF) for incongruent trials in two experimental conditions, without feedback (NO FB) and with feedbacks (FB) in ADHD group (upper part) and TD group (lower part). Error bars are mean standard errors.

group: ($F_{4,76} = 6.38$, $p < .001$, $\eta_p^2 = .25$) indicating that the delta-plots were different when comparing FB and NO FB conditions but as illustrated on Figure 4, the effect of feedback was different depending on the group.

In ADHD group, the interference effect decreased at the longest RTs in the FB condition (Congruency × Quintiles: $F_{4,72} = 4.46$; $p = .003$, $\eta_p^2 = .2$) whereas it remained globally stable across quintiles in the NO FB condition[6] (Congruency × Quintiles: $F_{4,72} = .2$; $p = .9$, $\eta_p^2 = .01$). Moreover, the between-condition comparison of the last quintile of the delta-plot confirmed that the interference effect at the slowest RTs was smaller in the FB than the NO FB condition ($t_{19} = 2.35$; $p < .05$). This suggests that the selective inhibition of the automatically activated response was improved by the delivery of positive feedback.

[6]The effect was observed in 61% of adolescents with ADHD.

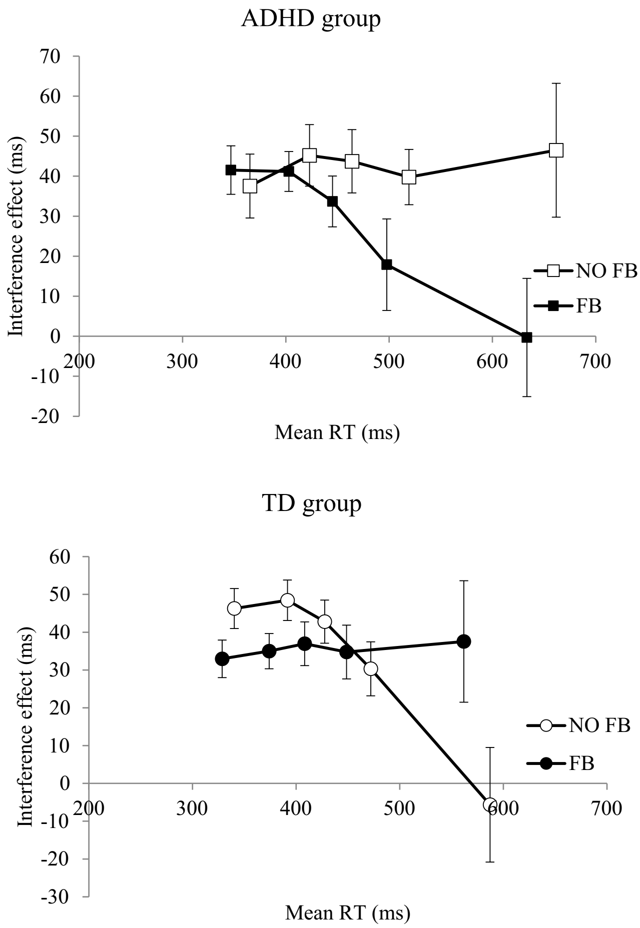

Figure 4. Distributional analysis of the interference effect. Delta plots showing interference effect size as a function of response speed, expressed in reaction time (RT) quintile scores, in two experimental conditions, without feedback (NO FB) and with feedbacks (FB) in ADHD group (upper part) and TD group (lower part). Error bars are mean standard errors.

In TD group, the interference effect decreased at the longest RTs in the NO FB condition[7] (Congruency × Quintile interaction: $F_{4,76} = 11.35$; $p < .00001$, $\eta_p^2 = .37$) (as usually observed) whereas it remained globally stable across quintiles in the FB condition (Congruency × Quintile interaction: $F_{4,76} = .08$; $p = .99$, $\eta_p^2 = .004$). This suggests that the selective inhibition of the automatically activated response was impaired in the FB condition compared to the NO FB condition. This was confirmed by the significant difference between the last quintile values of the two delta-plots ($t_{19} = 2.57$; $p = .02$). The interference effect at the slowest RTs was significantly larger in the FB than the NO FB condition[8]

[7]The effect was observed in 75% of TD adolescents.
[8]There was no effect of Order on the index of selective inhibition in both groups..

Table 2. Proportion of trials in which smiley was provided to participants (ADHD group and TD group) in congruent (CG) and incongruent (IG) trials.

	ADHD	TD
CG	68.8 (σ = 9.5)	71.7 (σ = 10.3)
IG	52.2 (σ = 12.6)	55.6 (σ = 12.3)
Total	60.5 (σ = 8.6)	63.6 (σ = 8.6)

Proportion of trials with smiley

Table 2 presents the proportion of trials in which smiley was provided in CG and IG trials and for both groups. A two-way ANOVA was performed on proportion of trials with smiley with Congruency (CG *versus* IG) as a within-subject factor and Group (ADHD *versus* TD) as a between-subjects factor. The proportion of trials with smiley was not significantly different between groups ($F_{1,\ 37} = 1.33$; $p = .25$, $\eta_p^2 = .02$) and it was significantly larger in CG trials than in IG trials ($F_{1,37} = 48.2$; $p < .0001$, $\eta_p^2 = .83$) for both groups (Congruency × Group: $F_{1,37} = 0.01$; $p = 0.91$, $\eta_p^2 < .001$).

Correlation coefficients were computed between smiley proportion and the major task outcomes: mean RT, accuracy rate, index of impulse capture and index of inhibition. We found a significant negative correlation between smiley proportion and the value of the first quintile in IG trials ($r_{39} = -.38$; $p = .017$) and a significant negative correlation between smiley proportion and mean RT ($r_{39} = -.29$; $p = .06$). This suggests that the more feedback was delivered, the lower the accuracy rate for the first quintile and the shorter mean RT.

Table 3. Correlation coefficients between the four major outcomes. IG Q1 accuracy = accuracy rate in IG trials for the fastest RTs. Delta Q5 value = interference effect value for the slowest RTs.

Control group, condition no feedback	Mean RT	Accuracy	IG Q1 accuracy (impulsivity index)	delta Q5 value (inhibition index)
Mean RT	1	.3 ; p= .19	.46 ; p= .04	.03 ; p= .87
Accuracy	.3 ; p= .19	1	.76 ; p< .001	*.37 ; p= .10*
Impulsivity index	.46 ; p=.04	.76 ; p< .001	1	.04 ; p= .84
Inhibition index	.03 ; p= .87	*.37 ; p= .10*	.04 ; p= .84	1
Control group, condition feedback				
Mean RT	1	.12 ; p= .59	.31 ; p= .17	*.39 ; p= .08*
Accuracy	.12 ; p= .59	1	.34 ; p= .14	.26 ; p= .27
Impulsivity index	.31; p=.17	.34 ; p= .14	1	-.02 ; p= .95
Inhibition index	*.39 ; p= .08*	.26 ; p= .27	-.02 ; p= .95	1
ADHD group, condition no feedback				
Mean RT	1	.31 ; p= .18	.34 ; p= .15	-.15 ; p= .53
Accuracy	.31 ; p= .18	1	.54 ; p= .017	.03 ; p= .88
Impulsivity index	.34 ; p= .15	.54 ; p= .017	1	-.15 ; p= .53
Inhibition index	-.15 ; p= .53	.03 ; p= .88	-.15 ; p= .53	1
ADHD group, condition feedback				
Mean RT	1	.32 ; p= .18	.21 ; p= .38	-.48 ; p= .03
Accuracy	.32 ; p= .18	1	.45 ; p= .04	-12 ; p= .62
Impulsivity index	.21 ; p= .38	.45 ; p= .04	1	-.06 ; p= .81
Inhibition index	-.48 ; p= .03	-12 ; p= .62	-.06 ; p= .81	1

Correlation analyses between the major task outcomes

Correlation coefficients were also computed between the four major task outcomes (mean RT, accuracy rate, impulse capture index and inhibition index) in both conditions and for each group (Table 3). In the NO FB condition, we mainly found a positive correlation between accuracy rate and the impulse capture index (accuracy rate for the first quintile in IG trials) in both groups. This means that the lower the global accuracy rate, the lower the accuracy rate for the shortest RTs, that is the higher the fast error rate. In the FB condition, the most relevant result was a significant negative correlation between RT and the inhibition index (interference effect for the last quintile of the delta-plot) in ADHD group, which suggests that when RTs were slower, the interference effect decreased, as predicted by the activation-suppression model.

Discussion

Effect of positive feedback on global performance

The experiment aimed to investigate whether positive feedback provided after each successful trial modulates the strength of response capture, and/or the ability to suppress it, in adolescents with ADHD and in TD adolescents. The overall performance analyses revealed that both groups of adolescents were faster, but committed more errors, in the FB than the NO FB condition. These data suggest an explanation in terms of speed-accuracy trade-off. Indeed, we cannot exclude the possibility that in the FB condition adolescents changed their strategy and chose to respond more rapidly, which then led them to be less accurate, even though instructions asked them to be as fast and as accurate as possible. The effect of feedback on accuracy rates was the same for CG and IG trials (no Congruency × Feedback interaction). This suggests that the increase in errors for CG as well as IG trials could come from an increased number of guesses.

Results also revealed that the size of the interference effect (mean CG RT – mean IG RT) on mean RTs was unaffected by the presence of feedback. This result could lead us to conclude that the presence of feedback did not improve interference control. However, the dynamic analysis of performance probed more deeply by allowing us to separately investigate the effect of increased motivation on the strength of impulse capture versus the selective suppression of impulsive action.

Effect of positive feedback on impulse capture

The dynamic analysis of accuracy, which provides information on the strength of impulse capture, revealed that both groups of adolescents committed more fast errors in the FB condition than in the NO FB condition. This suggests that the presence of feedback increased the strength of impulse capture, that is the susceptibility to activate automatic responses. This result was rather unexpected. Nonetheless, different studies using transcranial magnetic stimulation (TMS) over primary motor cortex have shown that reward elicits an increase in motor cortex excitability (Gupta & Aron, 2011; Klein et al., 2012; Mooshagian et al., 2015; Thabit et al., 2011). Some studies have even suggested that motor-evoked potentials (MEPs) could be used as objective correlates of motivation (Gupta & Aron, 2011; Kapogiannis et al., 2008). It is then possible that positive feedback increased cortical excitability, which in turn leads to more impulsive action and so increases the number of fast errors. This hypothesis is consistent with the fact that the effects of the Congruency and Feedback factors on mean RT were additive. Indeed, according to the additive factors method (AFM; Sanders, 1998; Sternberg, 1969), if two factors have additive effects on RT, it is assumed that they each affect a separate stage of the information processing chain. On the contrary, if the two factors have interactive effects, it is assumed that they each affect one or more stages in common. In our case, the effects were additive suggesting that congruency and the presence of feedback affected two different stages. Some have argued in the literature that congruency affects the response selection stage, in other words the decision stage (Adam, 2000; Burle & Bonnet, 1997; Hasbroucq et al., 1989, 1995, 1997; Rihet et al., 1999). Therefore, it is likely that the presence of feedback modulates a different stage, for example, the motor execution stage.

Nonetheless, an alternative hypothesis to explain fast guesses in FB condition could be linked to the reinforcement contingency. Indeed, participants received a smiley when the response was correct and the criterion for response speed was reached. Therefore, in the context of the experiment, making more fast errors on incongruent trials in the FB condition may be the best way to obtain the smiley. This is consistent with the fact that the number of smileys received in IG trials was significantly lower than in CG trials and close from chance (52% for ADHD group and 55% for TD group). This suggests that the adolescents made the choice to guess fast (and have a 50/50 chance to be correct) rather than being correct but missing the speed criterion. This could also explain the correlation observed between smiley proportion and accuracy rate for the first quintile. According to this hypothesis, making more fast errors on incongruent trials in the FB condition may be due to a strategic adaptation rather to a larger susceptibility to impulse capture. This explanation is consistent with data from a recent study using drift diffusion modeling (DDM) to examine how reinforcement and stimulant medication affect cognitive task performance in children with ADHD. DDM provides three different parameters including non-decision time (corresponding to stimulus encoding and motor response speed), boundary separation (corresponding to speed-accuracy trade-off) and drift rate (corresponding to information accumulation speed). Data have revealed that reinforcement reduced non-decision time compared to the no-reinforcement condition (Fosco et al., 2017). The authors proposed that the reinforcement condition emphasized speeded accuracy since more points were earned for responses that were accurate and fast than for those that were accurate but slow. Moreover, the same study has also shown that reward increased drift rate in children with ADHD but not in TD children suggesting that reward could also impact the efficiency of the decision-making process.

Effect of positive feedback on selective inhibition of impulsive action

The dynamic analysis of the interference effect showed that positive feedback had opposing effects on the selective inhibition of impulsive responses depending on the group of adolescents. While it improved selective inhibition in adolescents with ADHD, it impaired it in TD adolescents.

In the NO FB condition, data revealed that the interference effect remained stable over time in ADHD group while it decreased at longest RTs in TD group. The latter result is perfectly consistent with the literature and with the idea that selective inhibition of the response automatically activated by the position of the stimulus builds up progressively with time, as proposed by the "activation-suppression" model (Ridderinkhof, 2002). At the opposite, the effect observed in ADHD group showed that the inhibition of response capture did not occur even at the longest RTs, which suggests that adolescents with ADHD had difficulty in suppressing the response automatically activated by the position of the stimulus. This confirms data found in previous studies using dynamic analyses of performance to investigate interference control in children and adolescents with ADHD engaged in conflict tasks (Grandjean, Suarez, Diaz, et al., 2021; Grandjean, Suarez, Miquee, et al., 2021; Ridderinkhof et al., 2005), and therefore provides new evidence in favor of an inhibition deficit in adolescents with ADHD (Barkley, 1997; Nigg, 2001).

In the FB condition, data also revealed opposite effects between both groups. The interference effect decreased at the longest RTs in ADHD group whereas the decrease in the interference effect at the longest RTs disappeared in TD group. Concerning ADHD group, the data indicate that the interference effect decreased at the longest RTs in the FB condition. This suggests that delivering positive feedback at the end of each successful trial improved the efficiency of selective inhibition of impulsive responses. Therefore, our data confirm that increasing the level of motivation improved inhibitory processes. The positive impact of reinforcement on inhibition is consistent with data reported in several studies. For example, it has been shown that the performance level of children and adolescents with ADHD became similar to that of typically developing peers in a reward condition compared to a no reward condition during a stop-signal task (Konrad et al., 2000) and also in Go/No-Go tasks (Demurie et al., 2016; Groom et al., 2010). The inhibitory processes involved in stop-tasks and Go/No-Go tasks are different to those involved in conflict tasks. In stop-tasks, global inhibition (stopping all ongoing responses) is at play, while in conflict tasks, selective inhibition is required (stopping the incorrect response and continuing to make the correct one). These two types of inhibition have been shown to partially differ in terms of neural mechanisms and substrates (Aron, 2011; Aron & Verbruggen, 2008). Therefore, our findings extend existing data about the effect of reward on inhibition and suggest that not only global stopping, but also selective stopping, are improved by enhancing motivation. This is quite consistent with neurobiological knowledge indicating that both inhibition and motivation involve basal ganglia and its links with frontal structures (Chambers et al., 2009; Haber & Knutson, 2010; Knutson et al., 2001) such as anterior cingulate gyrus (for review, see Botvinick & Braver, 2015; Holroyd & Yeung, 2012; Kouneiher et al., 2009) and dorsolateral prefrontal cortex (Spielberg et al., 2012), structures that are also known to be involved in conflict monitoring. Similarly, the dopaminergic neurotransmitter is involved in inhibition (Aron, 2007) as well as in motivation (Botvinick & Braver, 2015).

It is also possible that the delivery of positive feedback indirectly acted on inhibition by acting on attentional processes more generally. For example, providing a smiley after each successful trial could have helped adolescents with ADHD to refocus their attention on the task, thereby improving inhibitory processes. Indeed, some data have already suggested that selective suppression might be under attentional control (Suarez, Vidal, et al., 2015b; Ward et al., 2005). Therefore, positive feedback could also improve inhibitory processes by indirectly improving attentional processes. To summarize, in adolescents with ADHD, the presence of positive feedback improved the selective inhibition of impulsive action but increased the strength of impulse capture. These two opposing effects could explain why we observed no difference in the interference effect between both conditions when performance was measured simply by mean RT.

Concerning TD adolescents, and quite surprisingly, in the FB condition, the decrease in the interference effect at the longest RTs disappeared. This unexpected result suggests that positive feedback provided at the end of each successful trial impaired selective inhibition of impulsive action. One explanation could be that since mean RT is shorter in the FB condition, suppression would not have had time to occur since the "activation-suppression model" hypothesizes that inhibition needs time to occur. However, Figure 4 clearly shows that in the NO FB condition, the slope of the delta-plot decreased for shorter RTs. An alternative explanation could be that the increase in motivation in TD adolescents could affect inhibitory processes. Although several studies have revealed enhancement of inhibition (Leotti & Wager, 2010), or an improvement in interference control, in rewarded conditions (Padmala & Pessoa, 2011), others failed to find this effect (van den Berg et al., 2014; Veling & Aarts, 2010) or found contradictory effects, that is an impairment of performance in rewarded conditions (Aarts et al., 2014; Krebs et al., 2010). To explain why motivation could have deleterious effects on cognitive control, some authors have proposed that individual differences in baseline dopamine level in the striatum of healthy adults could play an important role in the effects of motivation on cognitive control (Aarts et al., 2014). By referring to the hypothesis of optimal dopamine levels originally proposed by Cools and D'Esposito (2011), the authors proposed that in participants with low baseline dopamine levels, reward might increase dopaminergic processing, leading to optimal cognitive control. By contrast, in participants with a high baseline dopamine level, reward could "overdose" the dopaminergic system, leading to an impairment in cognitive control. In the present study, the effect of feedback could similarly "overdose" the dopaminergic system in TD adolescents, leading to impaired inhibitory processes, the opposite of what we had observed in adolescents with ADHD. It is likely that in adolescents with ADHD, known to have a dopaminergic deficit (Durston et al., 2008; Mick & Faraone, 2008), the delivery of feedback led to increase dopaminergic levels, and therefore to improved, near optimal, inhibitory control.The deleterious effect of reinforcement found in TD adolescents could be specific to inhibitory processes since several studies have also shown that reinforcement improved some other cognitive processes, such as working memory (Hammer et al., 2015; Magis-Weinberg et al., 2019) or sustained attention (Bubnik et al., 2015). This suggests that the efficiency of inhibitory processes could be sensitive to environmental factors, in particular to brain dopamine levels (Aarts et al., 2014; Cools & D'Esposito, 2011). Low DA brain levels, such as in adolescents with ADHD, as well as high DA brain levels such as in rewarded TD adolescents, would be deleterious for inhibitory processing. Inhibition would then depend on a very fragile balance of DA brain level. Therefore, the question of dopamine and inhibition deserves to be further investigated. Some studies have already demonstrated that both reinforcement and stimulant medication improve deficient response inhibition in children with ADHD and that the improvement is more efficient when medication and reinforcement are combined (Rosch et al., 2016). This is consistent with the idea that both methylphenidate (MPH) and reinforcement increase dopamine availability in the striatum (Arnsten & Rubia, 2012), an area strongly connected to frontal regions involved in inhibitory processes.

Conclusion and limitations of the study

The aim of the present study was to investigate how increased motivation could affect interference control in adolescents with ADHD and their typically developing peers and more specifically to dissociate the putative effect of motivation on both the expression and suppression of impulsive responses. Positive feedback delivered after each correct trial was used to manipulate motivation level. Results revealed that both groups of adolescents made more fast errors in the presence of positive feedback but that positive feedback improved selective inhibition in adolescents with ADHD while it impaired it in TD adolescents.

Put together, the data inspire several conclusions. First, in the present study we were able to dissociate the effect of motivation on the expression and suppression of impulsive action. We observed that these two components of interference control could be differentially affected by motivation. These data are in line with previous findings showing that these two components can be differently impacted by different manipulations (Fluchère et al., 2018; Grandjean, Suarez, Miquee, et al., 2021) and probably rely on different neural mechanisms and structures (Forstmann et al., 2008). Dissociating the effect of reward on the different component of interference control could have important implications for refining explanations of ADHD but could not have been possible if analyses were limited to evaluating overall performance.

Secondly, increasing motivation by delivering positive feedback in adolescents with ADHD improved inhibition but made them more susceptible to commit fast errors. Whatever the reason for this effect, it seems necessary to carry out further studies to more precisely determine whether some other kind of reward could enhance motivation without impairing other processes. For example, in the present experiment, feedback was delivered at the end of each successful trial but it could be relevant to explore whether the effects on impulse capture are the same when motivation is manipulated with delayed rewards.

Finally, there are at least two limitations to the present study. The first limitation refers to the fact that the experiment was carried out in adolescents diagnosed with combined ADHD. But it has been suggested that an inhibition deficit could depend on comorbid pathology and also on ADHD subtypes (Nigg et al., 2005; Scheres et al., 2001; Sonuga-Barke, 2002). Moreover, it seems that the effect of reward might also depend on ADHD subtypes (Dovis et al., 2015). Therefore, it seems necessary to extend our investigations to a larger population of patients including different subtypes of ADHD. The second limitation is partially related to the first one and concerns the sample size. Indeed, since ADHD group only included adolescents with combined ADHD and without comorbidities, the sample size was quite small and then the statistical power could be limited.

Acknowledgments

The authors warmly thank all the adolescents who accepted to participate in this study as well as Isabel Charvin who helped for selecting and contacting participants. They also wish to thank Jennifer Coull for her help with English language.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Aurélie Grandjean http://orcid.org/0000-0002-1504-7827
Isabel Suarez http://orcid.org/0000-0001-5579-0140
Laurence Casini http://orcid.org/0000-0002-2266-9034

References

Aarts, E., Wallace, D. L., Dang, L. C., Jagust, W. J., Cools, R., & D'Esposito, M. (2014). Dopamine and the cognitive downside of a promised bonus. *Psychological Science*, *25*(4), 1003–1009. https://doi.org/10.1177/0956797613517240

Adam, J. J. (2000). The additivity of stimulus–response compatibility with perceptual and motor factors in a visual choice reaction time task. *Acta Psychologica*, *105*(1), 1–7. https://doi.org/10.1016/S0001-6918(00)00042-1

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders. Forth Edition Revised (DSM IV-TR)*. Traduction française : Manuel diagnostique et statistique des troubles mentaux. Paris : Masson, 2004.

Arnsten, A. F., & Rubia, K. (2012). Neurobiological circuits regulating attention, cognitive control, motivation, and emotion: Disruptions in neurodevelopmental psychiatric disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(4), 356–367. https://doi.org/10.1016/j.jaac.2012.01.008

Aron, A. R. (2007). The neural basis of inhibition in cognitive control. *The Neuroscientist*, *13*(3), 214–228. https://doi.org/10.1177/1073858407299288

Aron, A. R., & Verbruggen, F. (2008). Stop the presses : Dissociating a selective from a global mechanism for stopping. *Psychological Science*, *19*(11), 1146–1153. https://doi.org/10.1111/j.1467-9280.2008.02216.x

Aron, A. R. (2011). From reactive to proactive and selective control : Developing a richer model for stopping inappropriate responses. *Biological Psychiatry*, *69*(12), e55–e68. https://doi.org/10.1016/j.biopsych.2010.07.024

Aron, A. R., Herz, D. M., Brown, P., Forstmann, B. U., & Zaghloul, K. (2016). Frontosubthalamic circuits for control of action and cognition. *The Journal of Neuroscience*, *36*(45), 11489–11495. https://doi.org/10.1523/JNEUROSCI.2348-16.2016

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions : Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Botvinick, 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. https://doi.org/10.1037/0033-295X.108.3.624

Botvinick, M., & Braver, T. (2015). Motivation and cognitive control : From behavior to neural mechanism. *Annual Review of Psychology*, *66*(1), 83–113. https://doi.org/10.1146/annurev-psych-010814-015044

Bubnik, M. G., Hawk, L. W., Jr., Pelham, W. E., Jr., Waxmonsky, J. G., & Rosch, K. S. (2015). Reinforcement enhances vigilance among children with ADHD: Comparisons to typically developing children and to the effects of methylphenidate. *Journal of Abnormal Child Psychology*, *43*(1), 149–161. https://doi.org/10.1007/s10802-014-9891-8

Burle, B., & Bonnet, M. (1997). Further argument for the existence of a pacemaker in the human information processing system. *Acta Psychologica*, *97*(2), 129–143. https://doi.org/10.1016/S0001-6918(97)00028-0

Burle, B., Possamaï, C.-A., Vidal, F., Bonnet, M., & Hasbroucq, T. (2002). Executive control in the Simon effect : An electromyographic and distributional analysis. *Psychological Research*, *66*(4), 324–336. https://doi.org/10.1007/s00426-002-0105-6

Burle, B., van den Wildenberg, W., & Ridderinkhof, K. R. (2005). Dynamics of facilitation and interference in cue-priming and Simon tasks. *The European Journal of Cognitive Psychology*, *17*(5), 619–641. https://doi.org/10.1080/09541440540000121

Cao, J., Wang, S., Ren, Y., Zhang, Y., Cai, J., Tu, W., Shen, H., Dong, X., & Xia, Y. (2013). Interference control in 6–11 year-old children with and without ADHD : Behavioral and ERP study. *International Journal of Developmental Neuroscience*, *31*(5), 342–349. https://doi.org/10.1016/j.ijdevneu.2013.04.005

Carter, C. S., Macdonald, A. M., Botvinick, M., Ross, L. L., Stenger, V. A., Noll, D., & Cohen, J. D. (2000). Parsing executive processes : Strategic vs. evaluative functions of the anterior cingulate cortex. *Proceedings of the National Academy of Sciences*, *97*(4), 1944–1948. https://doi.org/10.1073/pnas.97.4.1944

Casey, B. J., Thomas, K. M., Welsh, T. F., Badgaiyan, R. D., Eccard, C. H., Jennings, J. R., & Crone, E. A. (2000). Dissociation of response conflict, attentional selection, and expectancy with functional magnetic resonance imaging. *Proceedings of the National Academy of Sciences*, *97*(15), 8728–8733. https://doi.org/10.1073/pnas.97.15.8728

Chambers, C. D., Garavan, H., & Bellgrove, M. A. (2009). Insights into the neural basis of response inhibition from cognitive and clinical neuroscience. *Neuroscience & Biobehavioral Reviews*, *33*(5), 631–646. https://doi.org/10.1016/j.neubiorev.2008.08.016

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.

Conners, C. K. (1969). A teacher rating scale for use in drug studies with children. *The American Journal of Psychiatry*, *126*(6), 884–888. https://doi.org/10.1176/ajp.126.6.884

Cools, R., & D'Esposito, M. (2011). Inverted-U–shaped dopamine actions on human working memory and cognitive control. *Biological Psychiatry*, *69*(12), e113–e125. https://doi.org/10.1016/j.biopsych.2011.03.028

Demurie, E., Roeyers, H., Wiersema, J. R., & Sonuga-Barke, E. (2016). No evidence for inhibitory deficits or altered reward processing in ADHD : Data from a new integrated monetary incentive delay go/no-go task. *Journal of Attention Disorders*, *20*(4), 353–367. https://doi.org/10.1177/1087054712473179

Dickstein, S. G., Bannon, K., Castellanos, X., & Milham, M. P. (2006). The neural correlates of attention deficit hyperacticity disorder: An ALE meta-analysis. *Journal of Child Psychology and Psychiatry*, *47*(10), 1051–1062. https://doi.org/10.1111/j.1469-7610.2006.01671.x

Dovis, S., Van der Oord, S., Huizenga, H. M., Wiers, R. W., & Prins, P. J. M. (2015). Prevalence and diagnostic validity of motivational impairments and deficits in visuospatial short-term memory and working memory in ADHD subtypes. *European Child & Adolescent Psychiatry*, *24*(5), 575–590. https://doi.org/10.1007/s00787-014-0612-1

Durston, S., Fossella, J. A., Mulder, M. J., Casey, B. J., Ziermans, T. B., Vessaz, M. N., & Van Engeland, H. (2008). Dopamine transporter genotype conveys familial risk of attention-deficit/hyperactivity disorder through striatal activation. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(1), 61–67. https://doi.org/10.1097/chi.0b013e31815a5f17

Emond, V., Joyal, C., & Poissant, H. (2009). Neuroanatomie structurelle et fonctionnelle du trouble déficitaire d'attention avec ou sans hyperactivité (TDAH). *L'Encéphale*, *35*(2), 107–114. https://doi.org/10.1016/j.encep.2008.01.005

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*(1), 143–149. https://doi.org/10.3758/BF03203267

Fassbender, C., & Schweitzer, J. B. (2006). Is there evidence for neural compensation in attention deficit hyperactivity disorder? A review of the functional neuroimaging literature. *Clinical Psychology Review*, *26*(4), 445–465. https://doi.org/10.1016/j.cpr.2006.01.003

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Fluchère, F., Deveaux, M., Burle, B., Vidal, F., van den Wildenberg, W. P. M., Witjas, T., Eusebio, A., Azulay, J.-P., & Hasbroucq, T. (2015). Dopa therapy and action impulsivity : Subthreshold error activation and suppression in Parkinson's disease. *Psychopharmacology*, *232*(10), 1735–1746. https://doi.org/10.1007/s00213-014-3805-x

Fluchère, F., Burle, B., Vidal, F., van den Wildenberg, W., Witjas, T., Eusebio, A., Azulay, J.-P., & Hasbroucq, T. (2018). Subthalamic nucleus stimulation, dopaminergic treatment and impulsivity in Parkinson's disease. *Neuropsychologia*, *117*, 167–177. https://doi.org/10.1016/j.neuropsychologia.2018.02.016

Forstmann, B. U., van den Wildenberg, W. P. M., & Ridderinkhof, K. R. (2008). Neural mechanisms, temporal dynamics, and individual differences in interference control. *Journal of Cognitive Neuroscience*, *20*(10), 1854–1865. https://doi.org/10.1162/jocn.2008.20122

Fosco, W. D., White, C. N., & Hawk, L. W., Jr (2017). Acute Stimulant Treatment and Reinforcement Increase the Speed of Information Accumulation in Children with ADHD. Journal of abnormal child psychology, 45(5), 911–920. https://doi.org/10.1007/s10802-016-0222-0

Geurts, H. M., Luman, M., & van Meel, C. S. (2008). What's in a game : The effect of social motivation on interference control in boys with ADHD and autism spectrum disorders. *Journal of Child Psychology and Psychiatry*, *49*(8), 848–857. https://doi.org/10.1111/j.1469-7610.2008.01916.x

Grandjean, A., Suarez, I., Miquee, A., DaFonseca, D., & Casini, L. A. (2021). Differential response to pharmacological intervention in ADHD furthers our understanding of the mechanisms of interference control. *Cognitive Neuropsychology in Press*, *38*(2), 138–152. https://doi.org/10.1080/02643294.2021.1908979

Grandjean, A., Suarez, I., Diaz, E., Spieser, L., Burle, B., Blaye, A., & Casini, L. (2021). Stronger impulse capture and impaired inhibition of prepotent action in children with ADHD performing a Simon task: An electromyographic study. *Neuropsychology*, *35*(4), 399–410. in press. https://doi.org/10.1037/neu0000668

Groom, M. J., Scerif, G., Liddle, P. F., Batty, M. J., Liddle, E. B., Roberts, K. L., Cahill, J. D., Liotti, M., & Hollis, C. (2010). Effects of motivation and medication on electrophysiological markers of response inhibition in children with attention-deficit/hyperactivity disorder. *Biological Psychiatry*, *67*(7), 624–631. https://doi.org/10.1016/j.biopsych.2009.09.029

Gupta, N., & Aron, A. R. (2011). Urges for food and money spill over into motor system excitability before action is taken : Urges modulate motor excitability. *The European Journal of Neuroscience*, *33*(1), 183–188. https://doi.org/10.1111/j.1460-9568.2010.07510.x

Haber, S. N., & Knutson, B. (2010). The reward circuit : Linking primate anatomy and human imaging. *Neuropsychopharmacology*, *35*(1), 4–26. https://doi.org/10.1038/npp.2009.129

Hammer, R., Tennekoon, M., Cooke, G. E., Gayda, J., Stein, M. A., & Booth, J. R. (2015). Feedback associated with expectation for larger-reward improves visuospatial working memory performances in children with ADHD. *Developmental Cognitive Neuroscience*, *14*, 38–49. https://doi.org/10.1016/j.dcn.2015.06.002

Hart, H., Radua, J., Nakao, T., Mataix-Cols, D., & Rubia, K. (2013). Meta-analysis of functional magnetic resonance imaging studies of inhibition and attention in attention-deficit/hyperactivity disorder : Exploring task-specific, stimulant medication, and age effects. *JAMA Psychiatry*, *70*(2), 185. https://doi.org/10.1001/jamapsychiatry.2013.277

Hasbroucq, T., Guiard, Y., & Kornblum, S. (1989). The additivity of stimulus-response compatibility with the effects of sensory and motor factors in a tactile choice reaction time task. *Acta Psychologica*, *72*(2), 139–144. https://doi.org/10.1016/0001-6918(89)90040-1

Hasbroucq, T., Mouret, I., Seal, J., & Akamatsu, M. (1995). Finger pairings in two-choice reaction time tasks : Does the between-hands advantage reflect response preparation? *Journal of Motor Behavior*, *27*(3), 251–262. https://doi.org/10.1080/00222895.1995.9941715

Hasbroucq, T., Rihet, P., Blin, O., & Possamaï, C.-A. (1997). Serotonin and human information processing : Fluvoxamine can improve reaction time performance. *Neuroscience Letters*, *229*(3), 204–208. https://doi.org/10.1016/S0304-3940(97)00451-5

Hedge, A., & Marsh, N. W. A. (1975). The effect of irrelevant spatial correspondences on two-choice response-time. *Acta Psychologica*, *39*(6), 427–439. https://doi.org/10.1016/0001-6918(75)90041-4

Holroyd, C. B., & Yeung, N. (2012). Motivation of extended behaviors by anterior cingulate cortex. *Trends in Cognitive Sciences*, *16*(2), 122–128. https://doi.org/10.1016/j.tics.2011.12.008

Homack, S., & Riccio, C. A. (2004). A meta-analysis of the sensitivity and specificity of the Stroop Color and Word Test with children. *Archives of Clinical Neuropsychology*, *19*(6), 725–743. https://doi.org/10.1016/j.acn.2003.09.003

Hommel, B. (2011). The Simon effect as tool and heuristic. *Acta Psychologica*, *136*(2), 189–202. https://doi.org/10.1016/j.actpsy.2010.04.011

Jonkman, L. M., Kemner, C., Verbaten, M. N., Van Engeland, H., Kenemans, J. L., Camfferman, G., Buitelaar, J. K., & Koelega, H. S. (1999). Perceptual and response interference in children with attention-deficit hyperactivity disorder, and the effects of methylphenidate. *Psychophysiology*, *36*(4), 419–429. https://doi.org/10.1111/1469-8986.3640419

Kapogiannis, D., Campion, P., Grafman, J., & Wassermann, E. M. (2008). Reward-related activity in the human motor cortex. *The European Journal of Neuroscience*, *27*(7), 1836–1842. https://doi.org/10.1111/j.1460-9568.2008.06147.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL) : Initial reliability and validity data. *Journal of the American Academy of Child & Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Klein, P.-A., Olivier, E., & Duque, J. (2012). Influence of reward on corticospinal excitability during movement preparation. *Journal of Neuroscience*, *32*(50), 18124–18136. https://doi.org/10.1523/JNEUROSCI.1701-12.2012

Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *Journal of Neuroscience*, *21*(16), RC159. https://doi.org/10.1523/JNEUROSCI.21-16-j0002.2001

Konrad, K., Gauggel, S., Manz, A., & Schöll, M. (2000). Lack of inhibition : A motivational deficit in children with attention deficit/hyperactivity disorder and children with traumatic brain injury. *Child Neuropsychology*, *6*(4), 286–296. https://doi.org/10.1076/chin.6.4.286.3145

Konrad, K., & Eickhoff, S. B. (2010). Is the ADHD brain wired differently? A review on structural and functional connectivity in attention deficit hyperactivity disorder. *Human Brain Mapping*, *31*(6), 904–916. https://doi.org/10.1002/hbm.21058

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap : Cognitive basis for stimulus-response compatibility–A model and taxonomy. *Psychological Review*, *97*(2), 253–270. https://doi.org/10.1037/0033-295X.97.2.253

Kouneiher, F., Charron, S., & Koechlin, E. (2009). Motivation and cognitive control in the human prefrontal cortex. *Nature Neuroscience*, *12*(7), 939–945. https://doi.org/10.1038/nn.2321

Krebs, R. M., Boehler, C. N., & Woldorff, M. G. (2010). The influence of reward associations on conflict processing in the Stroop task. *Cognition*, *117*(3), 341–347. https://doi.org/10.1016/j.cognition.2010.08.018

Leotti, L. A., & Wager, T. D. (2010). Motivational influences on response inhibition measures. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(2), 430–447. https://doi.org/10.1037/a0016802

Luman, M., Oosterlaan, J., & Sergeant, J. A. (2005). The impact of reinforcement contingencies on AD/HD: A review and theoretical appraisal. *Clinical Psychology Review*, *25*(2), 183–213. https://doi.org/10.1016/j.cpr.2004.11.001

Luman, M., Tripp, G., & Scheres, A. (2010). Identifying the neurobiology of altered reinforcement sensitivity in ADHD: A review and research agenda. *Neuroscience and Biobehavioral Reviews*, *34*(5), 744–754. https://doi.org/10.1016/j.neubiorev.2009.11.021

Ma, I., van Holstein, M., Mies, G. W., Mennes, M., Buitelaar, J., Cools, R., Cillessen, A. H. N., Krebs, R. M., & Scheres, A. (2016). Ventral striatal hyperconnectivity during rewarded interference control in adolescents with ADHD. *Cortex*, *82*, 225–236. https://doi.org/10.1016/j.cortex.2016.05.021

Magis-Weinberg, L., Custers, R., & Dumontheil, I. (2019). Rewards enhance proactive and reactive control in adolescence and adulthood. *Social Cognitive and Affective Neuroscience*, *14*(11), 1219–1232. https://doi.org/10.1093/scan/nsz093

Mick, E., & Faraone, S. V. (2008). Genetics of attention deficit hyperactivity disorder. *Child and Adolescent Psychiatric Clinics of North America*, *17*(2), 261–284. https://doi.org/10.1016/j.chc.2007.11.011

Mooshagian, E., Keisler, A., Zimmermann, T., Schweickert, J. M., & Wassermann, E. M. (2015). Modulation of corticospinal excitability by reward depends on task framing. *Neuropsychologia*, *68*, 31–37. https://doi.org/10.1016/j.neuropsychologia.2014.12.021

Mullane, J. C., Corkum, P. V., Klein, R. M., & McLaughlin, E. (2009). Interference control in children with and without ADHD : A systematic review of flanker and simon task performance. *Child Neuropsychology*, *15*(4), 321–342. https://doi.org/10.1080/09297040802348028

Nigg, J. T. (2001). Is ADHD a disinhibitory disorder? *Psychological Bulletin*, *127*(5), 571–598. https://doi.org/10.1037/0033-2909.127.5.571

Nigg, J. T., Willcutt, E. G., Doyle, A. E., & Sonuga-Barke, E. J. S. (2005). Causal heterogeneity in attention-deficit/hyperactivity disorder : Do we need neuropsychologically impaired subtypes? *Biological Psychiatry*, *57*(11), 1224–1230. https://doi.org/10.1016/j.biopsych.2004.08.025

Oosterlaan, J., & Sergeant, J. A. (1998). Effects of reward and response cost on response inhibition in AD/HD, disruptive, anxious, and normal children. *Journal of Abnormal Child Psychology*, *26*(3), 161–174. https://doi.org/10.1023/a:1022650216978

Padmala, S., & Pessoa, L. (2011). Reward reduces conflict by enhancing attentional control and biasing visual cortical processing. *Journal of Cognitive Neuroscience*, *23*(11), 3419–3432. https://doi.org/10.1162/jocn_a_00011

Polanczyk, G., de Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: A systematic review and metaregression analysis. *The American Journal of Psychiatry*, *164*(6), 942–948. https://doi.org/10.1176/ajp.2007.164.6.942

Proctor, R. W. (2011). Playing the Simon game: Use of the Simon task for investigating human information processing. *Acta Psychologica*, *136*(2), 182–188. https://doi.org/10.1016/j.actpsy.2010.06.010

Ramdani, C., Carbonnell, L., Vidal, F., Béranger, C., Dagher, A., & Hasbroucq, T. (2015). Dopamine precursors depletion impairs impulse control in healthy volunteers. *Psychopharmacology*, *232*(2), 477–487. https://doi.org/10.1007/s00213-014-3686-z

Ratcliff, R. (1979). Group reaction time distributions and an analysis of distribution statistics. *Psychological Bulletin*, *86*(3), 446–461. https://doi.org/10.1037/0033-2909.86.3.446

Ridderinkhof, K. R. (2002). Activation and suppression in conflict tasks: Empirical clarification through distributional analyses. In W. Prinz, & B. Hommel (Eds.), *Common mechanisms in perception and action. Attention & performance, XIX* (pp. 494–519). Oxford University Press.

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*(2), 129–140. https://doi.org/10.1016/j.bandc.2004.09.016

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). The Guilford Press.

Ridderinkhof, K. R., Ullsperger, M., Crone, E. A., & Nieuwenhuis, S. (2004). The role of the medial frontal cortex in cognitive control. *Science*, *306*(5695), 443–447. https://doi.org/10.1126/science.1100301

Ridderinkhof, K. R., Scheres, A., Oosterlaan, J., & Sergeant, J. A. (2005). Delta plots in the study of individual differences: New tools reveal response inhibition deficits in AD/HD that are eliminated by methylphenidate treatment. *Journal of Abnormal Psychology*, *114*(2), 197–215. https://doi.org/10.1037/0021-843X.114.2.197

Ridderinkhof, K. R., Forstmann, B. U., Wylie, S. A., Burle, B., & van den Wildenberg, W. P. M. (2011). Neurocognitive mechanisms of action control: Resisting the call of the Sirens: Neurocognitive mechanisms of action control. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*(2), 174–192. https://doi.org/10.1002/wcs.99

Rihet, P., Hasbroucq, T., Blin, O., & Possamaï, C.-A. (1999). Serotonin and human information processing: An electromyographic study of the effects of fluvoxamine on choice reaction time. *Neuroscience Letters*, *265*(2), 143–146. https://doi.org/10.1016/S0304-3940(99)00231-1

Rosch, K. S., & Hawk, L. W., Jr. (2013). The effects of performance-based rewards on neurophysiological correlates of stimulus, error, and feedback processing in children with ADHD. *Psychophysiology*, *50*(11), 1157–1173. https://doi.org/10.1111/psyp.12127

Rosch, K. S., Fosco, W. D., Pelham, W. E., Jr., Waxmonsky, J. G., Bubnik, M. G., & Hawk, L. W., Jr. (2016). Reinforcement and stimulant medication ameliorate deficient response inhibition in children with attention-deficit/hyperactivity disorder. *Journal of Abnormal Child Psychology*, *44*(2), 309–321. https://doi.org/10.1007/s10802-015-0031-x

Sanders, A. F. (1998). Elements of human performance: Reaction processes and attention. In N. J. Mahwah (Ed.), *Self-Control in society, mind, and brain* (pp. 507–556). Erlbaum.

Scheres, A., Oosterlaan, J., & Sergeant, J. A. (2001). Response inhibition in children with DSM-IV subtypes of AD/HD and related disruptive disorders: The role of reward. *Child Neuropsychology*, *7*(3), 172–189. https://doi.org/10.1076/chin.7.3.172.8746

Simon, J. R. (1969). Reactions toward the source of stimulation. *Journal of Experimental Psychology*, *81*(1), 174–176. https://doi.org/10.1037/h0027448

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). North-Holland.

Slusarek, M., Velling, S., Bunk, D., & Eggers, C. (2001). Motivational effects on inhibitory control in children with ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*(3), 355–363. https://doi.org/10.1097/00004583-200103000-00016

Sonuga-Barke, E. J. S. (2002). Psychological heterogeneity in AD/HD—a dual pathway model of behaviour and cognition. *Behavioural Brain Research*, *130*(1–2), 29–36. https://doi.org/10.1016/S0166-4328(01)00432-6

Sonuga-Barke, E. J. S. (2003). The dual pathway model of AD/HD: An elaboration of neuro-developmental characteristics. *Neuroscience & Biobehavioral Reviews*, *27*(7), 593–604. https://doi.org/10.1016/j.neubiorev.2003.08.005

Spielberg, J. M., Miller, G. A., Warren, S. L., Engels, A. S., Crocker, L. D., Banich, M. T., Sutton, B. P., & Heller, W. (2012). A brain network instantiating approach and avoidance motivation. *Psychophysiology*, *49*(9), 1200–1214. https://doi.org/10.1111/j.1469-8986.2012.01443.x

Sternberg, S. (1969). The discovery of processing stages: Extensions of Donders' method. *Acta Psychologica*, *30*, 276–315. https://doi.org/10.1016/0001-6918(69)90055-9

Strand, M. T., Hawk, L. W., Jr., Bubnik, M., Shiels, K., Pelham, W. E., Jr., & Waxmonsky, J. G. (2012). Improving working memory in children with attention-deficit/hyperactivity disorder: The separate and combined effects of incentives and stimulant medication. *Journal of Abnormal Child Psychology*, *40*(7), 1193–1207. https://doi.org/10.1007/s10802-012-9627-6

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643–662. https://doi.org/10.1037/h0054651

Stürmer, B., Redlich, M., Irlbacher, K., & Brandt, S. (2007). Executive control over response priming and conflict: A transcranial magnetic stimulation study. *Experimental Brain Research*, *183*(3), 329–339. https://doi.org/10.1007/s00221-007-1053-6

Suarez, I., Burle, B., Tobon, C., Pineda, D., Lopera, F., Hasbroucq, T., & Casini, L. (2015a). Deciphering interference control in adults with ADHD by using distribution analyses and electromyographic activity. *Acta Psychologica*, *159*, 85–92. https://doi.org/10.1016/j.actpsy.2015.05.010

Suarez, I., Vidal, F., Burle, B., & Casini, L. (2015b). A dual-task paradigm to study the interference reduction in the Simon task. *Experimental Psychology*, *62*(2), 75–88. https://doi.org/10.1027/1618-3169/a000275

Thabit, M. N., Nakatsuka, M., Koganemaru, S., Fawi, G., Fukuyama, H., & Mima, T. (2011). Momentary reward induce changes in excitability of primary motor cortex. *Clinical Neurophysiology*, *122*(9), 1764–1770. https://doi.org/10.1016/j.clinph.2011.02.021

Tsal, Y., Shalev, L., & Mevorach, C. (2005). The diversity of attention deficits in ADHD: The prevalence of four cognitive factors in ADHD versus controls. *Journal of Learning Disabilities*, *38*(2), 142–157. https://doi.org/10.1177/00222194050380020401

Vaidya, C. J., Bunge, S. A., Dudukovic, N. M., Zalecki, C. A., Elliott, G. R., & Gabrieli, J. D. E. (2005). Altered neural substrates of cognitive control in childhood ADHD: Evidence from functional magnetic resonance imaging. *The American Journal of Psychiatry*, *162*(9), 1605–1613. https://doi.org/10.1176/appi.ajp.162.9.1605

van den Berg, B., Krebs, R. M., Lorist, M. M., & Woldorff, M. G. (2014). Utilization of reward-prospect enhances preparatory attention and reduces stimulus conflict. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(2), 561–577. https://doi.org/10.3758/s13415-014-0281-z

van den Wildenberg, W. P. M., Wylie, S. A., Forstmann, B. U., Burle, B., Hasbroucq, T., & Ridderinkhof, K. R. (2010). To head or to heed? Beyond the surface of selective action inhibition: A review. *Frontiers in Human Neuroscience*, *4*(222). https://doi.org/10.3389/fnhum.2010.00222

van Wouwe, N. C., Kanoff, K. E., Claassen, D. O., Spears, C. A., Neimat, J., van den Wildenberg, W. P. M., & Wylie, S. A. (2016). Dissociable effects of dopamine on the initial capture and the reactive inhibition of impulsive actions in Parkinson's disease. *Journal of Cognitive Neuroscience*, *28*(5), 710–723. https://doi.org/10.1162/jocn_a_00930

Veling, H., & Aarts, H. (2010). Cueing task goals and earning money: Relatively high monetary rewards reduce failures to act on goals in a Stroop task. *Motivation and Emotion*, *34*(2), 184–190. https://doi.org/10.1007/s11031-010-9160-2

Vincent, S. B. (1912). The function of the vibrissae in the behavior of the white rat. *Behavioral Monographs*, *1*(5), 1–181.

Ward, R., Danziger, S., Quirk, R. T., Goodson, L., & Downing, P. (2005). Suppression of involuntary spatial response activation requires selective attention. *Visual Cognition*, *12*(2), 376–394. https://doi.org/10.1080/13506280444000238

Wijnen, J. G., & Ridderinkhof, K. R. (2007). Response inhibition in motor and oculomotor conflict tasks: Different mechanisms, different dynamics? *Brain and Cognition*, *63*(3), 260–270. https://doi.org/10.1016/j.bandc.2006.09.003

Winer, B. J. (1970). *Statistical principles in experimental design*. MC Graw Hill Book.

Wylie, S. A., Ridderinkhof, K. R., Bashore, T. R., & van den Wildenberg, W. P. M. (2010). The effect of Parkinson's disease on the dynamics of on-line and proactive cognitive control during action selection. *Journal of Cognitive Neuroscience*, *22*(9), 2058–2073. https://doi.org/10.1162/jocn.2009.21326

Wylie, S. A., van den Wildenberg, W., Ridderinkhof, K. R., Claassen, D. O., Wooten, G. F., & Manning, C. A. (2012). Differential susceptibility to motor impulsivity among functional subtypes of Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, *83*(12), 1149–1154. https://doi.org/10.1136/jnnp-2012-303056

Wylie, S. A., Claassen, D., Kanoff, K., Ridderinkhof, K., & van den Wildenberg, W. (2013). Impaired inhibition of prepotent motor actions in patients with Tourette syndrome. *Journal of Psychiatry & Neuroscience*, *38*(5), 349–356. https://doi.org/10.1503/jpn.120138