Effortful Control – A Transdiagnostic Dimension Underlying Internalizing and Externalizing Psychopathology

Els Santens^{a, b} Laurence Claes^{b, c} Eva Dierckx^{a, d} Geert Dom^{b, e}

^aAlexian Psychiatric Hospital, Tienen, Belgium; ^bFaculty of Medicine and Health Sciences, University of Antwerp, Antwerp, Belgium; ^cDepartment of Clinical Psychology, Faculty of Psychology and Educational Sciences, KU Leuven, Leuven, Belgium; ^dDepartment of Clinical and Life Span Psychology, Faculty of Psychological and Educational Sciences, Vrije Universiteit Brussel, Brussels, Belgium; ^eMultiversum, Psychiatric Hospital, Boechout, Belgium

Keywords

Effortful control · Internalizing disorders · Externalizing disorders · Transdiagnostic dimension

Abstract

Effortful control (EC) or self-regulation refers to the ability to regulate behavior, emotion, and cognition. It has been identified as a contributor to both adaptive and adverse outcomes in children, adolescents, and adults and this across many domains. As such, it could be considered as a transdiagnostic dimension underlying internalizing (e.g., mood and anxiety disorders) and externalizing (e.g., substance use disorders, ADHD) psychopathology. We aimed to examine the role of EC throughout the adult psychopathological spectrum by means of a literature search of studies published between 2008 and 2018. Overall, the results point to the role of EC in the development of a broad spectrum of psychiatric diagnosis, reflecting the transdiagnostic characteristic of this construct. This role may be both directly causal or as a mediator factor influencing outcomes of a specific disorder. Early assessment of EC and early interventions to improve EC might help to avoid or decrease the risk of developing psychopathology.

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Introduction

The Research Domain Criteria (RDoC) framework [1, 2] grew out of a need to develop new ways of classifying mental disorders for research purposes, based on dimensions of observable behavior and measurable neurobiology. As such, the RDoC framework promotes taking underlying neurobiological factors into account when exploring their role in the pathogenesis of different phenotypic psychopathological presentations. One of the RDoC constructs that has received large attention is that of “control” within the cognitive RDoC domain. Control refers to a system that modulates the operation of other cognitive and emotional systems, in the service of goal-directed behavior, when prepotent modes of responding are not adequate to meet the demands of the current context. This connects closely with the concept of self-regulation (SR) which is considered to have an important role in adaptive and adverse outcomes in children, adolescents, and adults. In temperament research, the construct of “effortful control” is used for studying this SR in children and adolescents whereas in clinical neurocognitive research one uses the construct of “executive functioning” [3, 4].

Fig. 1. Figure illustrating the model of Rothbart [5].

In the psychobiological model of Rothbart (Fig. 1), temperament is defined as “constitutionally based individual differences in reactivity and SR, influenced over time by heredity, maturation and experience” [5]. Reactivity (e.g., punishment sensitivity related to negative affectivity, reward sensitivity related to positive affectivity, bottom-up regulation) includes responsiveness of emotional, activation, and arousal systems. In Gray’s Reinforcement Sensitivity Theory [6, 7], reactive dimensions of temperament are described in levels of behavioral approach system (BAS) and levels of behavioral inhibition system (BIS), whereby the BAS is sensitive for reward and the BIS is sensitive to punishment [8]. Higher BIS sensitivity is reflected in higher proneness to anxiety and is related to the personality trait of Neuroticism in the Five Factor Model (FFM) [9], elevated BAS sensitivity is reflected in elevated proneness to engage in goal directed efforts and to experience positive feelings and is related to the personality trait of Extraversion in the FFM [8–12]. Reactive temperament can be assessed using the Behavioral Inhibition System/Behavioral Activation System Scales (BIS/BAS) [8].

SR or effortful control (EC) involves the behaviors and processes that one uses to modulate one’s reactivity or reactions to stimuli [13, 14]. Whereas reactivity can be observed early in childhood, SR is developed later in life and progresses from simple reactive control to a more flexible, intentional, and self-directed use of attentional processes often referred to as EC [15]. This process parallels the maturation of the prefrontal cortex and may be conceptualized as top-down regulation of behavior. EC moderates the influence from BIS and BAS. As an aspect

of temperament, EC allows flexible regulation of thought, emotion, and is therefore strongly related to executive functioning [16–18].

EC is defined as “the efficiency of executive attention – including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and to detect errors” [13 p. 129]. The EC concept consists of 3 components: (1) attentional control which involves the ability to voluntarily focus or shift attention, (2) inhibitory control which is the ability to effortfully inhibit behavior, and (3) activation control which involves the ability to activate behavior even when one is not fully motivated [13, 14, 19]. Regulative temperament can be measured using the Effortful Control Subscale of the Adult Temperament Questionnaire (ATQ-EC) [20]. In sum, it can be stated that EC is the ability to approach a situation which one rather avoids and to inhibit actions which one desires [18] and can be seen as the fundamental basis of SR [15].

EC as a broad concept has been proven to be an important factor with respect to both normal, successful human development and the vulnerability to psychopathology [17] and thus covering a continuum from normality/normal range of personality to psychopathology. With respect to the pathogenesis of mental disorders, poor EC is associated with both internalizing and externalizing psychopathology, i.e. depression, bipolar disorder, eating disorders (ED), personality disorders (PD), ADHD, and addiction [17, 21–26]. Clinically, individuals with low levels of EC are at increased risk for multiple types of psychopathological symptoms across disease categories suggesting, EC can be seen as a transdiagnostic construct.

It is self-evident that impulse control-related diseases (ADHD, substance abuse, ED, behavior addictions) are characterized by disturbances of the inhibitory control component of the EC definition, but the attentional control and activation control components of the EC definition are also relevant aspects of EC in, e.g., the affective disorders.

Although it would be interesting to distinguish between the three components of EC in both internalizing and externalizing disorders, in most studies however the total sum of EC is used since the general concept of EC is of interest [27] and the alpha coefficients of the subscales are often too low, indicating that they are less reliable than the total score [28].

The neurobiological substrate of the EC network has been proposed to constitute of the anterior cingulate cortex (ACC) and the lateral prefrontal cortex [29–31]. This so-called executive attention network functions via top-down processes. The ACC is involved in the detection and monitoring of conflict, whereas lateral prefrontal areas have been shown to be mainly related to conflict resolution [32, 33]. In addition to the role of the ACC in the regulation of cognitive processing, this area appears to be also involved in the regulation of emotions [34] since activation in the dorsal part of the ACC has been seen when participants were performing a Stroop-like task, but in ventral areas when the task involved emotional stimuli [35].

The theoretical link between EC and the executive attention network has resulted in several studies investigating the link between EC self-reports (questionnaires) and performance on executive function tasks [36–38]. Concerning the self-report measures, EC is often measured using temperament questionnaires (self-report questionnaires, e.g. the Early Adolescent Temperament Questionnaire [EATQ] [39], and the Effortful Control Scale [ECS]) [40]. Another measure often used in studies with adults is the conscientiousness scale of the Big Five NEO-FFI [41]. Within the domain of the performance-based tasks, Fan et al. [42] developed the Attention Network Task (ANT) to assess the different attentional networks (and their interrelations) within a single task. More specific, the efficiency of alerting, orienting, and executive attention is measured by evaluating the impact of alerting cues, spatial cues, and flankers on reaction time. Another battery that is used for assessing EC in young children is the Kochanska's Battery for Assessing Effortful Control (Kochanska's EC battery). It has tasks that assess abilities for delaying or waiting, slowing down of gross and fine motor activity, suppressing or activating behavior, effortful attention, and lowering of voice or whispering [43]. In-

hibitory control is the component of EC that is most studied and which often uses parent or teacher questionnaires for assessing children's EC or for adults a self-report questionnaire (e.g., ECS) and behavioral tasks for measurement. Behavioral measures/neuropsychological measures often used to tap inhibitory control are the Go/No-Go task (requires responding to one frequent occurring stimulus and inhibiting a response to another less frequently occurring stimulus), the Stroop task (requires ignoring a dominant perceptual feature of a stimulus in favor of a subdominant feature, e.g. naming the color in which a word is printed, instead of reading the word), and the Stop-Go task (requires inhibition of an about-to-be-executed (prepared) motor response [44, 45] besides tasks to tap attentional control (i.e., attention focusing and attention control) [for an overview, see 18]. Another task to study conflict resolution is the flanker task in which a target stimulus is surrounded by irrelevant stimulation that can either match or conflict with the response required by the target [46].

Concerning the questionnaires, we found the Adult Temperament Questionnaire the most reliable and valid as it is known to have a good internal consistency and convergent validity with other measures of temperament and personality. The scale is divided into three subscales: inhibitory control, attentional control, and activation control. Internal consistency for the full scale in the original version was $\alpha = 0.78$ (inhibitory control $\alpha = 0.60$, attentional control $\alpha = 0.73$, and activation control $\alpha = 0.69$) [28]. Normative data for EC have been reported in a large non-clinical sample ($n = 700$) [20].

Regarding the performance-based tests, the following measurements have proven the most reliable and valid indicators of EC: Stroop Color and Word test [47], the Go/No-Go Task and the Stop Signal Task [45].

Questionnaires and behavioral measures of inhibition in general show small to moderate correlations, and results seem to depend on the type of neuropsychological measure that is used to tap executive functions. Another explanation of the low correspondence of no correspondence could be that temperament questionnaires measure rather more general identity-related beliefs about experience, whereas neuropsychological tasks assess the momentary situation-related behavioral performance [23, 48, 49]. There is some evidence for a positive relationship between EC and executive attention, but especially when parent reports of the EC of their child are considered. Some research studies therefore question the interchangeability of EC questionnaires and neuropsychological executive functioning tasks when measuring EC [50].

Fig. 2. Flow chart.

Taken together, EC is considered an important construct within the RDoC cognitive system domain, and cross-sectional studies show its involvement in a broad spectrum of traditional-categorical (DSM-ICD) psychiatric diagnoses. From this perspective, EC might be considered as a prototypical transdiagnostic dimension. However, no recent review has been published exploring the role throughout the adult psychopathological spectrum. Within the current work, we aimed at exploring its role in both internalizing and externalizing psychiatric disorders.

Methods

Our narrative review was based upon a literature search in the database PubMed for studies published with search terms EC and adults and clinical disorders (internalizing and externalizing disorders, mood disorders, depressive disorders, anxiety disorders, ED, impulsive disorders, ADHD, substance use disorder (SUD), and behavioral disorders (i.e., gambling, internet gaming, compulsive internet use [CIU], and compulsive buying [CB]). Limits were set in time, between 2008 and 2018, adult age (>18 years) and English. We only included original research papers that reported well-accepted self-report questionnaires or behavioral measures for EC. The combination of the aforementioned search items led to the identification of 29 articles (Fig. 2).

For each study, relevant data, extracted by the first author, addressed the characteristics and findings of the selected studies. Findings are reported for each pathology/psychiatric diagnosis separately, and only significant findings are reported (Table 1).

Results

In total, 29 unique original research articles were included in this review.

EC and Mood and Anxiety Disorders

Reactive (i.e., punishment sensitivity/negative affectivity, reward sensitivity/positive affectivity) and regulative (EC and attentional mechanisms) temperament factors are increasingly being seen as possible mechanisms underlying increased vulnerability to depression and anxiety [9, 51, 52].

The study of Dinovo and Vasey [53] provides evidence for extending a temperamental model for depression and anxiety to adults. They also stress the importance of taking the regulatory component of temperament, namely EC, into account in understanding the association between temperamental activity and depressive and anxious disorders. They found that persons high

Table 1. Study characteristics, outcome measures, and main findings

First author [Ref.], year	Sample, <i>n</i> , and setting	EC measure	Parts a-c Total	Other measures of EF	Questionnaires PBT	Measures specific for pathology	Main findings
Mood disorders							
Dinovo [53], 2011	477 undergraduate students	ECS-P/LD (persistence/low distractibility subscale)	Part a Part c	BIS/BAS Attentional Control Scale (ACS)	Only questionnaires: ECS + ACS	Balanced Inventory of Desirable Responding (BIDR) Mood and Anxiety Symptom Questionnaire (MASQ) T-PANAS (Positive and Negative Affect Schedule Trait form)	Ineg. reactivity, lpos. reactivity, IEC, Ianhedonia, Igeneral distress Main and moderating effect of EC Note: inhibitory control (part b) was not measured EC was represented by a composite formed by averaging the standardized item scores from the ACS and the EC P/LD scale ($\alpha = 0.90$; $r = 0.45$, $p < 0.001$)
Nishiguchi [55], 2016	Students T1: 178 T2: 115	ATQ-EC	Part a Part b Part c	Need for cognition scale	Only questionnaires ATQ-EC	SDS; Zung	TEC on T1, I depressive symptoms on T2 INic; IEC in depressed patients Moderating effect of EC Correlations between depressive symptoms, all subscales of EC, EC, and Nic were significant Further analyses were performed with EC total sum
Arger [57], 2012	315 non clinical young adults	ATQ			Only questionnaires ATQ-EC	Cognitive Style Questionnaire (CSQ) Ruminative Response Scale (RRS); brooding subscale Perseverative Attention to Negative Events (PANE) Center for Epidemiologic Studies Depression Scale (CEDS)	EC: no moderating role
Kanske [58], 2012	142 HC 5 dropouts	ATQ-EC		Visual Flanker Test Auditory Simon Test (Use of Conflict of Emotion Conflict); RT fMRI ERP	Questionnaires: ATQ-EC Performance based Measures: ERP fMRI	Depression Anxiety Stress Scales (DASS)	TEC, faster in solving flanker and Simon types of conflict TEC, IERP, I conflict negativity in incongruent trials TEC, faster conflict resolution in both neg. and pos. emotional stimuli TEC, IERP conflict negativity in emotional trials Association of EC with greater activity in ventral ACC in emotional neg. stimuli TD and A, I speed in conflict processing in neg. emotional trials IERP conflict negativity in negative emotional trials in high D and A scores EC: moderating effect Total sum of EC was used Interindividual differences in temperamental effortful control, anxiety, and depression assessed in questionnaires were consistently associated with the experimental effects Effortful control also correlated directly with conflict processing in both flanker and Simon tasks
Marchetti [59], 2018	RMD = 90 HC = 270	ATQ-EC Attention Network Task (ANT)			Questionnaires ATQ-EC Performance-based measures ANT (Fan et al. [42])	BDI STAI	IEC I depressive and anxiety symptoms in whole sample (MDD = HC) I Executive Attention, I depressive symptoms in whole sample Executive Attention: RMD = HC EC: main effect Total sum of EC was used
Anxiety disorders							
Tortella-Feliu [54], 2012	32 young adults	ATQ-EC			Only questionnaires ATQ-EC	PANAS Ruminative Response Scale White Bear Suppression Inventory Online emotion rater (VAS) (50 days)	TNA, I worry, anxiety, avoidance, self reported rumination and suppression IEC, I worry, anxiety, avoidance, EC: Moderating effect for the association between negative affect and avoidance Total sum of EC was used
Clements [56], 2010	509 undergraduate university students	ATQ-EC	Part a Part b Part c		Only questionnaires ATQ-EC	STAI	TNA, I anxiety TEC, I PA, I anxiety EC: main effect Total sum of EC was used in further analyses, not the subscales
Bipolar disorder							
Burdick [61], 2008	24 outpatients with either bipolar I or II disorder 24 HC				Performance based measures: Stroop Color Word Task Cued Target Detection Effortful attention variables: Stroop Color Word Task d2 test of attention Psychomotor assessment: Reaction Time testing Speed of finger oscillation Finger and hand dexterity	SCID-IV Ham-D Automatic attention: Cued Target Detection Effortful attention variables: Stroop Color Word Task d2 test of attention Psychomotor assessment: Reaction Time testing Speed of finger oscillation Finger and hand dexterity	Effortful attention BP < effortful attention HC Psychomotor functioning BP < psychomotor functioning HC Automatic attention BP = HC

Table 1 (continued)

First author [Ref.], year	Sample, <i>n</i> , and setting	EC measure	Parts a-c Total	Other measures of EF	Questionnaires PBT	Measures specific for pathology	Main findings
Eating disorders							
Müller [62], 2012	90 extremely obese patients	ATQ-EC	Reactive T: BIS/BAS	Executive inhibition processes: Switching of Attention Task Verbal Interference Task (Stroop) Verbal List Learning Task Go/No-Go Task Reactive inhibition: BIS/BAS	Only questionnaires ATQ-EC	EDE-Q PHQ WURS ADHD-SR	IEC, Irregular binge eating Prevalence ADHD regular BE = prevalence ADHD not BE Regular BE: not higher BAS or lower BIS as BE group BE: more depression EC: main effect Total sum of EC was used
Burt [65], 2015	160 Age: 18–25 y Non-clinical sample	ATQ-EC			Only questionnaires ATQ-EC	Eating Disorder Examination Questionnaire (EDE-Q)	IEC, IED TNE and IEC, IED EC: main effect on ED EC moderates link between NE and ED symptoms
Claes [23], 2012	48 ED female inpatients	ATQ-EC	Part a Part b Part c	Use of IntegNeuro for Executive inhibition processes: Switching of Attention Task Verbal Interference Task (Stroop) Verbal List Learning Task Go/No-Go Task Reactive inhibition: BIS/BAS	Questionnaires: ATQ-EC Performance based Task Use of IntegNeuro		IEC, TT for Trail Making Test/Stroop, more reaction time variability on Go/No-Go Task, IED, binge-purging behavior Main effect of EC Binge-purging behavior significantly higher levels of attention and motor inhibition Problems compared to restrictive patients, + showed a lack of interference control and motor control + showed more behavioral inhibition problems
Zwaan [67], 2015	923 overweight or obese participants	ECS	Reactive T: BIS/BAS		Only questionnaires ATQ-EC	Patient Health Questionnaire-Depression Weight cycling	IBAS, TBM, 1weight suppression, 1depressive symptoms, 1binge eating EC severe weight cyclers = EC non weight cyclers No effect of EC Total sum was used in analysis
Turner [68], 2014	145 ED patients	ATQ-ES Total sum	BIS/BAS		Only questionnaires ATQ-EC	Eating disorder-related symptoms Utrecht Coping List SCL-90 ADP-IV	Undercontrolled/dysregulated group: IBIS, 1BAS, low EC Overcontrolled/disinhibited group: IBIS, 1BAS, moderate EC Resilient group: IBIS, moderate BAS, 1EC Moderating effect of EC Total sum of EC was used
Matton [69], 2017	252 adolescents	ATQ-ES	Part a Part b Part c	Color-Word-Stroop Task SPSSRQ	Questionnaires: ATQ-EC Performance based Task: CWST	Adjusted BMI	Boys: ISR, 1restrained eating; ISR, 1external eating Girls: ISR, 1restrained eating, IEC, 1EC, 1external eating ISP, ISR, 1interference control, 1restrained eating EC as moderator Total sum of EC was used The self-reported EC-total score was not correlated with interference control measured with the Stroop task
Müller [70], 2014	93 bariatric surgery candidates 63 obese inpatients	ATQ-EC	Reactive Temperament: BIS/BAS Stroop Color Word Task		Questionnaires: ATQ-EC Performance based tasks: SCWT	Binge Eating Disorder Module of Eating Disorder Examination (EDE) SCID Eating Disorder Examination Questionnaire (EDEQ) PHQ Patient Health Questionnaire depression scale ADHDS symptoms: – Wender Utah Rating Scale (WURS) – ADHD-SR – CAARS Iowa Gambling Task Stroop Color Word Task (comp) The Labyrinth Test	IEC, 1avoidance and approach: resilient/high functioning group = Cluster 1 IEC, 1avoidance and approach: emotionally dysregulated/undercontrolled group = Cluster 2 More psychopathology, 1eating disorders, 1BED, 1ADHD, 1depressive scores Impulse Control Disorders: CL 1 = CL 2 EC as moderator Total sum of EC was used Both questionnaires and neurocognitive testing for executive functioning: low to non-correlations between these measures

Table 1 (continued)

First author [Ref.], year	Sample, <i>n</i> , and setting	EC measure	Parts a–c Total	Other measures of EF	Questionnaires PBI	Measures specific for pathology	Main findings
Substance use disorder Piehler [73], 2012	998 adolescents Alcohol Nicotine Marihuana	ATQ-R-EC (adolescent, parent, and teacher)			Only questionnaires ATQ-EC	Adolescent Substance Use Early-Adulthood Problematic Substance Use CIDI (Composite International Diagnostic Interview): substance use/dependence for each substance Peer Interaction Task	1EC in adolescence, 1level of problematic substance use in early adulthood marihuana/nicotine/ substance use lifestyle EC as moderator Total sum of EC was used
Wong [74], 2013	644 undergraduate students	ATQ-EC	Part a Part b Part c		Only questionnaires: ATQ-EC	General Causality Orientation Scale (GCOS) Drinking and other Drug Use History Questionnaire (DDHQ)	Autonomy orientation positively predicted effortful control, which was associated with a decrease in the expected frequency of drinking Controlled orientation negatively predicted effortful control, which was associated with an increase in the expected frequency of drinking Controlled orientation predicted the presence of alcohol-related problems and illicit drug use EC as mediating effect Total sum of EC was used
Walters [77], 2018	196 young adults	EC		Eysinck Impulsivity Scale	Only questionnaires: ATQ-EC	Plan to abstain Self-control demands	No association between EC and alcohol consumption or self-control demands
Simons [78], 2018		Regulative T SSRQ		Reactive T Eysenck BIS	Only questionnaires: ATQ-EC		Effortful control acts as a buffer, reducing associations between intoxication and unprotected intercourse EC as moderator Total sum of EC was used
Kahn [79], 2018	1,903 university students	ATQ	Part a Part b Part c	BIS/BAS	Only questionnaires: ATQ-EC	Substance use behavior	1PS, 1EC (inhibitory control), 1A, 1marihuana Only factor inhibitory control (EC) acts as a moderator
Mun [80], 2018	311 adolescents and their families	EATQ-R; Ellis & Rothbart, 2001			Only questionnaires: EATQ-R	Parent-child relationship quality (P-C RQ); ages 11 to 13) Parental monitoring (ages 11 to 13) Early adulthood problematic substance abuse (ages 18–19 to 26–27); interview items from the Composite International Diagnostic Interview	1P-C RQ, 1EC 1EC in adolescence, 1problematic substance use in early adulthood EC as mediator Total sum of EC was used
Adkison [81], 2013	277 families Father alcohol problem Father no alcohol problem	Stroop Color Word Task SSRT Tower of London (TOL)		Tower of London (TOL)	Only performance-based tasks: SCWT SSRT TOL	UM-CIDI (The University of Michigan Composite International Diagnostic Interview) to assess parental alcohol problems DSM-IV criteria for alcohol dependence/abuse Antisocial Behavior Checklist to assess fathers antisocial behavior	EC in boys with FA status <EC in boys in control group EC as moderator
ADHD Graziano [82], 2015	555 students (mean age 20 y)	ATQ-EC			Only questionnaires ATQ-EC	CAARS (ADHD screening college students) Sensation Seeking Scale (SSS) National Survey on Drug Use and Health Questionnaire Driving Behavior Questionnaire (DBQ) Sexual Risk Survey (SRS) Compulsive Buying Scale (CBS) Credit Card Misuse Scale (CCMS)	1ADHD symptoms + 1EC → risky behavior Only questionnaires EC as mediator Total sum of EC was used
Burden [83], 2010	102 young adults			Go/No-Go task ERP	Only performance based tasks: ERP		Childhood ADHD diagnosis: inhibitory control ADHD-prenatal alcohol: 1P3 difference between No-Go and Go (ERP) EC as main effect; poorer inhibitory control was seen
Marquard [84], 2018	27 ADHD 28 HC			Modified flanker test	Only performance-based tasks Modified flanker test	ASRS	ADHD: 1P3 in incompatible trials, 1ERN, 1Pe amplitudes Low inhibitory control and attentional control EC as main effect

Table 1 (continued)

First author [Ref.], year	Sample, <i>n</i> , and setting	EC measure	Parts a–c Total	Other measures of EF	Questionnaires PBT	Measures specific for pathology	Main findings
Impulse control disorders							
Claes [63], 2011	211 female students	ATQ	Part a Part b Part c	BIS/BAS	Only questionnaires: ATQ-EC	Compulsive Buying Scale Eating Disorder Inventory Physical Health Questionnaire-depression	IEC, ICB, IED IBIS, IED IBAS, ICB EC as main effect (low levels of inhibitory and activation control)
Müller [86], 2014	102 outpatients with CB	ATQ-EC		BIS/BAS	Only questionnaires: ATQ-EC	CBS Patient Healthcare Questionnaire-depression scale Material Value Scales (MVS)	IBAS, ↑ depressive symptoms, ↑ maternalism: ICB No correlation between low EC and CB Total sum of EC was used
Voith [88], 2014	31 patients Control nonclinical <i>Compulsive buying</i>	ATQ-EC		<i>Reactive Temperament</i> BIS/BAS IGT <i>Regulative Temperament</i> ATQ-EC Verbal Interference Test (Stroop)	Questionnaires: ATQ-EC Performance based tasks Stroop	CBS PHQ-9 (Patient Health Questionnaire Depression Scale)	<i>Reactive and regulative temperament: self-ratings and performance-based tasks</i> IEC, IBIS, IBAS, IGT performance in CB compared to HC <i>Relationship between self-reports and performance-based tasks</i> No significant associations were found between any of the self-reported and performance based measures EC as main effect Total sum of EC was used
Claes [87], 2011	60 ED female outpatients	ATQ-EC (short form)	Part a Part b Part c		Only questionnaires ATQ-EC	CBS Dutch Compulsive Internet Use Scale EDI BIS/BAS	IEC, ↑ emotional lability, ↑ excitement seeking, ICB and ICU Main effect of EC Subscales of EC: low levels of inhibitory control and activation control in CB and ICU; ICU also significantly related to lack of attentional control

EC, effortful control; EF, executive functioning; PBT, Performance Based Task. EC subscales: part a = attentional control; part b = inhibitory control; part c = activation control.

in negative reactivity, low in positive reactivity, and low in EC were especially vulnerable for symptoms of depression. Overall, the authors showed an important role of EC in internalizing (depressive, anxious) symptoms, i.e. both as a main effect and as a moderator of the effect of reactive aspects of temperament (BIS/BAS). Of note, this was a (large: $n = 477$) study in undergraduate students (as part of their academic curriculum), not an identified patient sample, exploring symptoms and not disorders. High levels of negative affect and low levels of EC were also associated with higher levels of anxiety in a study by Tortella-Feliu et al. [54], whereby the prospective association between negative affectivity and avoidance was moderated by EC (high negative affect being related to engaging in avoidance behaviors only for those exhibiting low EC). In a longitudinal study in university students, Nishiguchi et al. [55] explored the temporal relationship between EC, depressive symptoms, and cognitive motivation (need for cognition [NfC]). NfC is a personality trait related to one's motivation to enjoy effortful cognitive activity. Their findings suggest a temporal relation whereby depressive symptoms caused a decrease in EC both as a main effect and indirectly, mediated by cognitive motivation. This finding could imply that a motivational deficit may partially explain the decreased EC found in depressed patients. Their results moreover showed that the indirect effect of depressive symptoms was significant for all EC subscales. Since inhibition control, activation control and attentional control all require some cognitive effort, the decline of NfC associated with depressive symptoms may predict less efficiency of all aspects of EC.

Clements and Bailey [56] studied the relationship between anxiety and aspects of temperament in their effort to develop a profile that may be used to identify individuals at risk. In their large sample (509 undergraduate students), high positive affect and high EC correlated with low levels of reported anxiety. Another study performed in non-clinical young adults examined the relationship between negative emotionality and depressive symptoms through mediation or moderation of cognitive vulnerability factors (cognitive style, brooding, stress-reactive rumination) and EC but found no moderating role of EC between negative emotionality and cognitive vulnerability factors [57].

A study of Kanske and Kotz [58] showed that EC as a temperamental trait and subclinical depression and anxiety together influence the emotional modulation of executive attention. Participants high in EC and low in depression and anxiety, especially, responded faster to con-

flict processing (flanker test, Simon task) in emotional stimuli, showed an enhanced ERP conflict negativity, and additional (fMRI) increased activation in the ventral ACC. Of note, this was a study in healthy controls (HC) where subclinical depressive and anxious symptoms were explored, not a clinical population with distinct mood or anxiety disorders. Marchetti et al. [59] compared EC and attentional networks in remitted depressed patients (RMD) and HC as measured with the Adult Temperament Questionnaire-Effortful Control (ATQ-EC) and the ANT. In their sample of 90 RMD and 270 HC, high EC was substantially associated with less depressive and anxiety symptoms regardless of clinical status (i.e., RMD vs. HC) while less efficient executive attention was modestly associated with more depressive complaints in the whole sample. Of interest, no differences were found in EC between HC and RMD. The negative correlation between depressive symptoms and EC could represent an attentional dysfunction, as attentional bias especially for negative information [60] and diminished attentional control are associated with depression.

EC and Bipolar Disorder

Burdick et al. [61] performed a study on 24 patients with bipolar I or bipolar II disorder (both in the depressive phase), and an HC group with performance-based tasks in order to measure attention and psychomotor functioning. Relative to the HC, the bipolar sample demonstrated evidence of psychomotor slowing and revealed deficits on measures of effortful attention, yet demonstrated comparable performance on measures of automatic attention. These results suggest an attentional impairment during the depressed phase of bipolar disorder that may be specific to effortful processing, while automatic processes remain relatively intact. Murphy et al. [64] found manic patients were impaired in their ability to inhibit behavioral responses (low levels of inhibitory control, subcomponent of EC) and focus attention, but depressed patients were impaired in their ability to shift the focus of attention and exhibited an affective bias for negative stimuli (low levels of attentional control, subcomponent of EC).

EC and ED

Aspects of reactive and regulative temperament also play an important role in the etiology of ED. EC is one of the constructs most often named in research investigating the development and maintenance of ED. Several studies found individuals with high NA and low EC are more at risk for developing ED symptomatology [63–65]. Low EC

was also found to be associated with impulsiveness in binge/purging ED [63, 66].

As mentioned above, several studies showed that high NA and low EC place individuals at risk for developing ED symptomatology.

Zwaan et al. [67] investigated the association between reactive and regulative aspects of temperament and severe weight cycling in overweight and obese individuals. They found that higher reward sensitivity/BAS was associated with more severe weight cycling, but no association or moderating effect with EC was found. In a study concerning the role of temperamental factors in binge eating in obese patients, patients with regular binge eating reported a significantly lower level of EC compared with patients without binge eating [63]. Interestingly, the binge eating group did not show lower BIS and/or higher BAS scores (reactive temperament), both related to more impulsivity. The study of Turner et al. [68] identified 3 distinct groups of ED patients based on measures of reactive temperament and EC: an overcontrolled/inhibited group (high BIS, low BAS, moderate EC), an undercontrolled/dysregulated group (high BAS, moderate BAS, low EC), and a resilient group (high EC, moderate BAS, low BIS). Patients in the undercontrolled/dysregulated group demonstrated more severe symptoms of bulimia, hostility and Cluster B Personality Disorders compared to the other groups.

In a recent study within a community sample of adolescents (14–19 years), Matton et al. [69] examined the moderating role of EC in the association between sensitivity to punishment and sensitivity to reward and the eating styles restrained eating, emotional eating, and external eating as possible eating disorder precursor. Although some evidence was found for an interaction with EC in girls, main effects in both boys and girls were found for sensitivity to punishment and sensitivity to reward. Müller et al. [70] distinguished two temperament subtypes in a sample of treatment-seeking obese individuals (a cluster high in EC and low in punishment and reward sensitivity (reactivity) and a cluster low in EC and high in punishment and reward sensitivity). In the cluster low in EC, more co-morbid psychopathology (ADHD, binge eating, and depressive symptoms) was found.

EC and SUD

A vulnerability to disinhibition also seems to be a core risk factor associated with both the initiation and continuation of SUD [71]. Two neural systems are involved: one involving EC, localized in prefrontal cortical circuitry, and one involving incentive reactivity (reward sensi-

tivity), localized in subcortical circuitry [26]. In a recent study, Santens et al. [72] combined measures of reactive and regulative measures to establish subgroups of adult inpatients with SUDs and could identify a “resilient” group (high EC, low BAS, low BIS), an “anxious” group (low EC, high BIS, moderate BAS), and a “reward-sensitive” group (moderate EC, high BAS, moderate to low BIS). The “anxious” group had the highest levels of clinical symptomatology.

In a longitudinal study that was part of a larger interventional study, Piehler et al. [73] found that higher levels of EC in adolescence ($n = 998$) were related to less problematic substance use in early adulthood (tobacco and marijuana). Although this effect was not significant for alcohol use, the interaction between EC and exposure to a “substance use lifestyle” was significant for problematic alcohol use in early adulthood. In another study in undergraduates, Wong and Rowland [74] examined the relationship between two motivational orientations (autonomy and controlled orientations within the Self-Determination Theory of Ryan and Deci [75, 76]), the role of EC and substance use among students. Autonomy orientation, also called intrinsic motivation, positively predicted EC, which was associated with a decrease in the expected frequency of drinking. In contrast, controlled orientation negatively predicted EC, which was associated with an increase in the expected frequency of drinking. Controlled orientation or extrinsic motivation also significantly predicted the presence of alcohol-related problems and illicit drug use via EC. Overall, although no main effect was reported, EC significantly mediated the effects of autonomy orientation and controlled orientation on frequency of alcohol use. In another recent study by Walters et al. [77] in 196 young adults, EC was not significantly associated with alcohol consumption. In addition, in a study by the same group, EC exhibited a protective effect, reducing the effects of alcohol intoxication on the likelihood of unprotected intercourse [78]. In a large ($n = 188$) study among university students, Kahn et al. [79] investigated whether components of EC serve unique roles in moderating the link between reward and punishment sensitivity and substance use behaviors. In this study of emerging adults, inhibitory control (ATQ measured) was the only component of EC that emerged as a significant moderator.

Different studies explored the effect of early family context or a family history of SUD on the risk for developing substance use problems. In a longitudinal study (from age 11 to 27), Mun et al. [80] found that higher levels of adolescent EC were associated with lower problematic substance use.

In their sample of 277 families, Adkison et al. [81] used only behavioral tasks to measure EC (Stroop task, Stop-Go Task, Tower of London). Their results indicate that especially sons of fathers with an alcohol problem have lower levels of EC which makes them particularly vulnerable to poor self-regulatory strategies.

Taken together, the majority of studies exploring the relationship between EC and substance use support the hypothesis that lack of EC is associated with an increased risk for the development of addictive behaviors. However, findings are not consistent, and none of the studies we found included patients with SUD.

EC and ADHD

In the etiology of ADHD, both neurocognitive and temperamental factors have been implicated. However, studies on EC within adult ADHD remain remarkably scarce within the timeframe 2008 and 2018.

Within a large student sample, Graziano et al. [82] showed an association between the severity of ADHD symptoms and risky behavior but only when EC was low. However, it needs to be noted that this study relates to ADHD symptoms (as assessed with a screening instrument) and not to individuals with a formal ADHD diagnosis.

In another study, Burden et al. [83] assessed response inhibition in a sample of young adults diagnosed with ADHD by studying Event Related Potentials (ERP) during a classic Go/No-Go task. In terms of behavioral performance, poorer inhibitory control was evident in participants with childhood ADHD both with and without prenatal alcohol exposure, as reflected in poorer accuracy when attempting to withhold the button press to No-Go. Analysis of the ERPs revealed a markedly diminished P3 difference between No-Go and Go in the young adults with a history of ADHD but no prenatal alcohol exposure (the idiopathic ADHD group). In a study using ERP deviations of electrophysiological measures, Marquardt et al. [84] suggested reduced effortful engagement of attentional and error-monitoring processes in adults with ADHD. Associations between ADHD symptom scores, event-related potential amplitudes, and poorer task performance in the ADHD group further support this notion.

EC and Behavioral Addictions

Given the recent increase of interest in behavioral addictions, we decided to include a broader spectrum of behavioral addictive patterns than currently included in the DSM or ICD classification [85].

As several studies showed an association between EC and CIU and CB, Claes et al. [63] investigated the relationship between CB and CIU in a sample of 60 patients with an ED. They found a significant association between CB and CIU. Concerning reactive temperament, they could not find a significant association between CB/CIU and BIS, but CIU was significantly related to BAS drive and CB almost significantly positively related to BAS fun seeking. Concerning regulative temperament, both CB and CIU were characterized by lack of EC, more specifically by low levels of inhibitory control. In a sample of CB outpatients, however, Müller et al. [86] surprisingly found no association between low EC and CB. They found an association between BAS, high materialism and especially depression scores. Claes et al. [87] found on the other hand in a sample of female patients with an eating disorder a positive correlation between low level of EC and CB.

In CB, a deficit in SR might also be a potential risk factor. Therefore, temperamental features are thought to be underlying factors associated with CB. In a small study, Voth et al. [88] investigated reactive and regulative temperament in a sample of treatment seeking CB patients combining temperament questionnaires and performance-based tasks. In the CB group, they found lower levels of EC (regulative temperament) and higher levels of BIS and BAS (reactive temperament) in comparison with the control group. The CB group performed worse on the Iowa Gambling Task (IGT) [89] compared to the control group, which suggests a tendency toward disadvantageous decisions and a higher sensitivity to immediate reward in the CB-group that may reflect higher BAS-reactivity. In the Stroop task, no group differences could be found. They found no significant associations between the questionnaire-based results and the outcomes of the behavioral tasks.

EC and Psychotic Disorders or Schizophrenia

Despite the known relevance of attentional impairments in psychotic patients [90], no studies were identified using measures for EC in psychotic patient samples.

EC and Obsessive-Compulsive Disorders

In the PubMed search, we did not find studies of OCD.

According to Gray's personality model, OCD is defined as an anxiety problem driven by the BIS in combination with a lack of attentional control (subscale of EC) [91].

Discussion and Conclusion

Our literature search yielded 31 studies covering different clinical disorders. Most frequently studied in consecutive order were mood and anxiety, substance use, and ED. Very few studies were found on adult ADHD and none in patients with psychotic disorders. Overall, the results of the included studies point to a role of EC in the pathogenesis of psychiatric disorders. The role of EC was different throughout different studies, i.e. EC as a main effect, as a moderator or as a mediator. Based on these findings, EC seems to confirm its transdiagnostic dimension cutting through both internalizing and externalizing disorder categories. However, caution should be taken in interpretation. By far most of the studies were performed within non-pathological student samples, exploring relations with disorder symptoms – not disorders. Very few studies included individuals with diagnosed disorders.

EC has been identified as a contributor to both adaptive and adverse outcomes in children, adolescents, and adults and this across many domains. EC seems to affect maladjustment by contributing to the processing of information, as well as to the modulation of emotion and behavior. The ability to divert attention from negative thoughts and to focus on affectively neutral or positive thoughts and activities, for example, seems to be important to experience less negative emotion and has been linked to low levels of anger, anxiety, and depression [92–94]. Engaging in a new activity or focusing on new stimuli appears to reduce distress [95, 96]. The ability to focus attention is also likely to aid in planning behavior, and can help to deal with stressful situations. Attentional control may be especially important for reducing internalizing symptoms such as sadness and anxiety. In addition, the ability to effortfully inhibit behavioral impulses is important for reducing externalizing problems [97, 98]. Although it would be interesting to distinguish between the three components of EC (attentional control, inhibitory control, and activation control) in both internalizing and externalizing disorders, in most studies, however, the total sum of EC is used since the general concept of EC is of interest [27] and the alpha coefficients of the subscales are often too low, indicating that they are less reliable than the total score [28]. We only found three studies where analyses were made with the three subcomponents of the EC [23, 79, 87].

How EC deficits contribute to the different pathogenic processes remains to be understood, with some studies indicating a more direct causal relation and others with EC as a mediator factor modifying the effect of other vul-

nerabilities. Likewise, its role with regard to specific psychopathology versus a common factor influencing severity and chronification of different disorders remains to be explored.

Although not the topic of the current study, the role of EC in the pathogenesis of PD, increasingly, is highlighted. Claes et al. [11] investigated the association of both reactive and regulative (EC) temperament with PD and found that all PD were characterized by low levels of EC, cluster C PD by high BIS and cluster B PD by high BAS. For several PD, BIS and EC interacted: BIS was only related to severe PD pathology if EC was low. Another study found low EC in relation to borderline PD [99]. In an earlier study, De Panfilis et al. [100] showed a specific role for EC as a mediator between rejection sensitivity and its subsequent interpersonal distress on borderline personality features in an adult community sample, suggesting that low SR capacities may enhance interpersonal distress in response to rejection.

The construct of EC based on Rothbart's temperament model is the same across the different studies. Only assessment methods of EC differed especially concerning the performance-based tasks, while only the ATQ-EC was used as questionnaire. EC can be measured by self-report questionnaires and behavioral/neurocognitive tasks. In the studies cited above, however, the authors concluded that no significant associations could be found between personality (temperament questionnaire) and neuropsychological measures of executive/reactive inhibition [23, 70]. This is in line with the overall findings within the neuropsychological literature indicating that questionnaires and behavioral tasks do not measure the same underlying construct and therefore should not be used interchangeably [23]. Given that many studies included in this review were done within (large) student samples, most of them used mainly self-report scales, i.e. with the ATQ-EC as most prominent. As to the behavioral measures different tasks were used which are characteristically used within the study of inhibitory processes, e.g. Stroop or SST. However, it can be questioned whether these tasks are specifically mapping EC or other dimensions. This question relates to another, i.e. the exact nature or definition of EC and how it differentiates from executive control. Taken together, measuring EC falls into the same limitations that are also prominent in other neuropsychological dimensions. Both the conceptual unity and the use of different instruments highlight the need for a consensus definition and subsequent standardized measuring method highly needed to allow for comparison of findings over different studies.

EC has been largely understudied in adults compared with the neuropsychological research on executive functioning. Some authors, however, call for an integrated model of SR combining the temperament framework using measures of "effortful control" and the "executive function" framework given the conceptual and empirical overlap between EC and executive functioning [16, 18, 49, 101]. Nigg [17] also states that executive functioning, EC, and cognitive control are closely related. Working memory is also part of or closely related to EC [17, 18] possibly due to shared involvement of executive attention. Bridgett et al. [16] also showed that EC is related to the executive function of updating/monitoring information in working memory. They also found that high EC and better updating/monitoring information in working memory were linked to lower dispositional negative affect.

Research further shows that poor effortful/cognitive control is significantly related to reduced structural and neural activity in prefrontal cortices [102], whereby this reduced activity in the PFC correlates with various psychiatric disorders [103]. These findings are consistent with recent neurobiological studies that identified a common neural circuit disruption in cognitive control across psychiatric disorders [104, 105]. The findings of these studies demonstrate a common pattern of disruption across major psychiatric disorders that parallels the "multiple-demand network" observed in intact cognition [104, 105]. The authors suggest that neuropsychological performance, gray matter volume, and functional brain activation converge to implicate transdiagnostic disruptions in neurocircuitries underlying general cognitive capacity.

Many limitations should be taken into account with regard to the interpretation of the results. First of all, we based our search on one database (PubMed). Although we think this is a valid choice given our focus on EC and psychiatric disorders, the use of additional databases might provide a more comprehensive overview. The current work thus cannot be considered as a systematic review but as an exploration of the possible role of EC throughout different diagnostic categories. Second, despite a large number of studies within student and healthy control groups, the paucity of studies focusing on psychiatric disorders in adult individuals is striking. So, findings from these student samples should be very carefully used when reflecting adult psychopathology. Further, we found no study comparing patient groups with different disorders (or temperaments). Most studies are highlighting differences between patient groups and HC. However, exploring differences between targeted patient groups may yield important additional information on the role

of EC dimension in the pathogenesis of different disorders. Finally, throughout different studies different conceptualizations for EC are used and often overlap with constructs that are also used in other constructs, i.e. executive functioning. A better delineation between the different neuropsychological constructs and their assessment methods is badly needed to further explore the details and subtleties of the underlying mechanisms in psychopathology [17, 106].

Taken together, the concept of EC can be seen as a universal psychological dimension covering a continuum from normality to psychopathology and this across disease categories. We found indications that EC is an important psychological dimension within adult psychopathology, cutting through the boundaries of both internalizing and externalizing diagnostic categories. Its role may be both directly causal or as a mediator factor influencing severity and prognosis of a specific disorder. Early assessment of EC and early interventions to improve EC might help to avoid or decrease the risk on developing a broad spectrum of psychiatric disorders.

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The authors have no ethical conflicts to disclose.

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Santens E. performed a literature search in the database PubMed, extracted relevant data and provided summaries of the research studies. Santens E. wrote the first draft of the manuscript, and all authors contributed to and have approved the final manuscript.

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