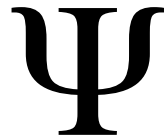**DET PSYKOLOGISKE FAKULTET**

Ψ

Impaired Cognitive Inhibition in First Episode Major Depressive Disorder

HOVEDOPPGAVE

profesjonsstudiet i psykologi

Eirin Kolberg

Vår 2015

Veileder

Åsa Hammar

Table of contents

Abstract

The aim of this study was to investigate cognitive inhibition in first episode major depressive disorder (MDD) at a one-year follow-up. Fifty-three participants were assessed on the Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A) and the Color Word Interference Test (CWIT) one year after first being diagnosed with MDD. Previous studies of the same sample have shown that the patient group, especially those who relapsed, had impaired inhibition performance as measured by the CWIT, even after remission. This study investigated self-reported inhibition, as well as general executive functioning, measured by BRIEF-A. The patient group (n=26) reported more problems with inhibition and general executive functioning than controls (n=27), despite remission from other depressive symptoms. CWIT inhibition scores did not correlate with BRIEF inhibition, but did correlate with the BRIEF Global Executive Composite. There was no significant difference between the BRIEF-A scores of those who had relapsed and those who had not. These results support previous findings of persistent deficits after remission, but it is possible that the two measures should be treated as complimentary, not interchangeable, measures of inhibition in MDD. Inhibition has promise in the study of MDD, but needs to be carefully defined.

Sammendrag

Målet med denne studien var å undersøke kognitiv inhibisjon ved depressiv lidelse ett år etter første episode. Femtitre deltagere ble undersøkt med Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A) og Color Word Interference Test (CWIT). Tidligere studier med samme utvalg har vist at deprimerte, og spesielt de som opplevde tilbakefall i løpet av det påfølgende året etter første episode, hadde dårligere skåre enn kontrolldeltagere på inhibisjon målt med CWIT, selv etter remisjon. Denne studien undersøkte selvrapportert inhibisjon, i tillegg til selvrapportert eksekutiv-funksjon mer generelt, med BRIEF-A. Pasientgruppen ($n = 26$) rapporterte flere problemer med inhibisjon og generell eksekutiv-funksjon enn kontrollgruppen ($n = 27$), på tross av remisjon fra øvrige symptomer. CWIT-skårer korrelerte ikke med inhibisjons-skåre fra BRIEF-A, men korrelerte med det generelle målet på eksekutiv-fungering. Det var ingen forskjell mellom skårene til de som hadde tilbakefall, og de som ikke hadde tilbakefall på BRIEF-A. Resultatene støtter tidligere funn om varig kognitiv svekkelse etter remisjon, men det kan være at de to forskjellige målene bør behandles som ulike og komplementære mål på inhibisjon ved depresjon. Inhibisjon ser ut til å være et relevant fokusområde i studier av depresjon, men bør defineres mer presist.

Major depressive disorder (MDD) is a debilitating illness with an estimated lifetime prevalence of 11.1%-14.6% globally (Bromet et al., 2011). It is associated with significant negative consequences in a number of areas, including occupational performance (Baune et al., 2010; Preiss et al., 2009), social functioning (Segrin, 2000) and quality of life (Gostautas, Pranckeviciene, & Matoniene, 2006), as well as being linked to morbidity and mortality for a number of diseases (Lépine & Briley, 2011). MDD also constitutes a large economic burden to society in the form of direct and indirect healthcare costs (Sobocki, Jönsson, Angst, & Rehnberg, 2006), lower work productivity even after remission (Adler et al., 2006), and a reduced workforce due to disablement (Ferrari et al., 2013). Depression is considered the second largest cause of disability world wide (Ferrari et al., 2013). The burden on the individual and on society is compounded by the high rate of relapse and chronicity of depression; more than 75% will have more than one episode (Boland & Keller, 2009), with about 50% relapsing within the first two years of an initial episode (Mueller et al., 1999). Naturally, mechanisms involved in the development of depression, in causing related disability and increasing risk of relapse are of great interest. Cognitive impairment has been associated with these different aspects of depression, and may possibly serve as a link between them.

There is broad consensus that depression involves cognitive impairment in important domains such as memory, attention, psychomotor- and processing-speed, and problem solving (Austin, Mitchell, & Goodwin, 2001; Baune, Fuhr, Air, & Hering, 2014; Hammar & Årdal, 2009; Lee, Hermens, Porter, & Redoblado-Hodge, 2012; Papakostas, 2014). Previous studies have indicated that deficits in executive function are present in the first episode of depression, specifically impairments on the measures

of inhibition and semantic fluency (Schmid & Hammar, 2013a). These executive function deficits were found to persist despite symptom recovery after one year (Schmid & Hammar, 2013b). Impaired performance during the acute phase on an inhibition task with additional demands on cognitive flexibility was found to differentiate between depressed participants who relapsed within a year and those who did not (Schmid & Hammar, 2013b). Thus, poor performance on this inhibition measure may reflect a cognitive impairment linked to the risk of relapse in MDD.

The current study further examined the role of inhibition in depression. The measure of inhibition in the study that found persistent impairment (Schmid & Hammar, 2013b) was the Color Word Interference Test (CWIT) from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). The present study looked at the self-reported inhibition deficits for this same sample on the Behavior Rating Inventory of Executive Function–Adult Version (BRIEF-A; Roth, Isquith, & Gioia, 2005). It aimed to investigate whether impairments detectable in controlled testing environments are associated with comparable problems in daily life, addressing the unity of the inhibition construct as well as its utility in the study of depression vulnerability, disability and relapse. There are a number of conceptual and methodological obstacles to defining and investigating the presence, type and impact of cognitive impairment, but increasing evidence indicates that it may be a central part of understanding the depression cycle (Austin et al., 2001; Baune et al., 2014; Hammar & Årdal, 2009; Jaeger, Berns, Uzelac, & Davis-Conway, 2006).

Cognitive Impairment in Depression

The subjective experience of depression frequently involves reduced mental acuity, articulated in the Diagnostic and Statistical Manual of Mental Disorders-IV

(DSM-IV; American Psychiatric Association, 2000) as "diminished ability to think or concentrate, or more indecisiveness" (p.356). It is also generally accepted that cognitive content such as negative automatic thoughts and schemas play an important role in depression (Scher, Ingram, & Segal, 2005). Biased information processing in the domains of attention, appraisal and memory are well established as characteristics of the depressive cycle (Gotlib & Joormann, 2010; Mathews & MacLeod, 2005). Many studies have indicated that individuals with depression may be more vulnerable to these kinds of biased information processing, particularly when experiencing stress or negative affect (Ingram, 2003; Scher et al., 2005). However, research has suggested that affective disorders are associated with impairments in a number of important cognitive domains that exceed what can be explained by the affective symptoms and stress-related biases in information processing (Preiss et al., 2009; Thompson et al., 2005). Suboptimal functioning of central cognitive processes may constitute an important source of vulnerability in depression.

There are a number of reasons why cognitive impairment in depression is of interest. The proposed roles for cognitive impairment include (a) a link with psychosocial disability; (b) a link with illness characteristics and outcomes; and (c) a vulnerability to depressive episodes. Relevant in all these areas is the relative stability and independence of cognitive impairment from other symptoms. These elements will be discussed in turn before exploring whether executive functions, and more specifically inhibition, is a good way to conceptualize this deficit.

Psychosocial disability. It has been shown in a variety of psychiatric conditions, including depression, that neuropsychological deficits impede life functioning in many areas, including, work, education, family relationships and other social relations

(Hammar & Årdal, 2009; Jaeger et al., 2006). Some studies have indicated that cognitive impairment may be the largest source of psychosocial disability for people with MDD by impairing occupational performance (McIntyre et al., 2013; Preiss et al., 2009). Both self-reported and objectively measured cognitive impairments have been found to be unique and strong predictors of disability in MDD, particularly in the area of *physical disability*, which involves impediments to physical activity, daily routines, and hobbies (Naismith, Longley, Scott, & Hickie, 2007).

It is not just during acute depressive episodes that MDD has been associated with reduced psychosocial functioning. Judd, Paulus, Wells, and Rapaport (1996) found that the disability for subsyndromal depression was equal to that of clinical depression, implying a role for a more persistent disadvantage. Impaired cognitive functioning may be persistent, occur independently of affective symptoms, and contribute to psychosocial disability beyond the effects of other symptoms. There are indications that cognitive symptoms do not always subside at the same rate as other symptoms, and might persist even after remission from MDD (Austin et al., 2001; Baune et al., 2010; Bhardwaj, Wilkinson, Srivastava, & Sharma, 2010; Bortolato, Carvalho, & McIntyre, 2014; Hammar & Årdal, 2009; Neu et al., 2005; Reischies & Neu, 2000), which could mean that the detrimental consequences for daily social, occupational and academic activities continue even after the other symptoms are reduced. Sarapas, Shankman, Harrow, & Faull (2013) have reported that cognitive performance could predict social functioning for people with depression after 18 years, even when controlling for baseline social functioning and symptoms of depression. Jaeger et al. (2006) found that neuropsychological impairments during hospitalization for MDD predicted disability in life functioning 6 months later. Not all studies have found the persistence of cognitive

symptoms after remission (Biringer et al., 2005; Neu et al., 2005), so causes of these discrepancies warrant further research.

It is possible that these psychosocial consequences in themselves contribute to increased stress and persistent illness, for example through less social support and thus reliance on less effective coping strategies (Jaeger et al., 2006). Reduced cognitive function may, however, also impair the ability to self-regulate, cope and problem solve more directly (Gotlib & Joormann, 2010). More knowledge on the topic could help determine whether interventions aimed at remediating or living with reduced cognitive function are useful ways to reduce disability in MDD.

Outcomes and illness characteristics. There are indications that, in addition to disability, cognitive impairment is correlated with other important MDD illness characteristics, such as chronicity, the number of relapses and long-term average severity (Bhardwaj et al., 2010; Buist-Bouwman et al., 2008; Sarapas et al., 2013; Fennig & Mottes, 2002). In a recent review of the literature, Papakostas (2014) found multiple and consistent indications that cognitive deficits were associated with earlier onset, longer duration and impediment to treatment and functional recovery. Schmid and Hammar (2013b) found that in first episode depression, cognitive functioning was related to the risk of relapse within a year. Some exceptions do exist; Reischies and Neu (2000) found no such correlation between cognitive functioning and duration of disease or number of episodes, despite persistence of impairment after remission and a relatively high median age of the participants (*Md* = 53.7 years). Determining when and how cognitive functioning is impaired in depression, and how it relates to illness characteristics, may offer valuable insights into the heterogeneity of MDD outcomes.

Vulnerability to depressive episodes. The association between poorer cognitive functioning and depression has been demonstrated repeatedly, but the exact nature of this relationship is complex. Three commonly cited hypotheses will be discussed briefly, as any possible causality is central to understanding the role of cognitive impairment in depression. The relationship between cognitive dysfunction and depression has been variously posited as a mood-dependent effect, a detrimental consequence of depression, or a more stable trait that constitutes a predisposition to depression.

Cognitive impairment as mood-dependent effect. It has been suggested that mild residual affective symptoms could be a factor contributing to apparent cognitive deficits in remission for bipolar patients (Clark, Iversen, & Goodwin, 2002). Scheurich et al. (2008) argued for a motivational origin of cognitive impairment in major depression, related to mood, task specific self-efficacy, and interest. However, motivation and effort have not always been found to co-vary with the symptoms (Jaeger et al., 2006). Furthermore, after controlling for mood effects and for hypercorticolaemia, the impairments on a number of cognitive tests were still significant for MDD and bipolar disorder (Gorwood, Corruble, Falissard, & Goodwin, 2008; Jaeger et al., 2006; Thompson et al., 2005). For remitted patients, it has been reported that the concurrent levels of depressive symptoms were unrelated to cognitive impairment (Preiss et al., 2009; Schmid & Hammar, 2013b). Thus residual mood-dependent effects do not appear to explain all cognitive difficulties.

Cognitive impairment as a consequence of detrimental effects on the brain caused by depression, possibly resulting from neurotoxic effects. There is some research suggesting that depression has a detrimental effect on cognitive function,

specifically the fact that impairments have been found to correlate with the number of previous episodes (Kessing, 1998), get worse with each episode (Baune et al., 2010) and to correlate with the duration of the illness (Elgamal, Denburg, Marriott, & MacQueen, 2010; Gorwood et al., 2008; Sweeney, Kmiec, & Kupfer, 2000; Thompson et al., 2005). In a longitudinal study, past but not current symptom severity correlated with cognitive deficits, and cognitive impairment did not fluctuate with the other symptoms (Sarapas et al., 2013).

The detrimental effects of depression might involve endocrine and autonomic changes. One common finding in depression is hypersecretion of corticotropin-releasing factor (CRF) and consequently hyperactivity of the hypothalamic-pituitary-adrenocortical (HPA) axis and sympathic activation (Arborelius, Owens, Plotsky, & Nemeroff, 1999; Gillespie & Nemeroff, 2005; Nemeroff, 1988). A review by Schlosser, Wolf and Wingenfeld (2011) found moderate support for the hypothesis that HPA-related changes are linked to cognitive performance, as 14 out of 20 studies reported significant correlations between these. Central to the dysregulation of the HPA is an excess of corticosteroids, which have the potential to cause neural damage and to negatively impact cognitive and affective function (Herbert et al., 2006). This, however, does not mean that depressive episodes themselves cause this damage. HPA-function, commonly linked to stress, may be influenced by genetic factors as well as life events (Herbert et al., 2006). In addition, cognitive impairment has been reported as early as the first episode in MDD (Hammar & Årdal, 2009; Lee et al., 2012), indicating that not all cognitive impairment can be explained simply by the detrimental effects of long term illness.

Cognitive impairment as the reflection of a trait or other vulnerability to

depression. In addition to being reported in first episode MDD (Hammar & Årdal,

2009; Lee et al., 2012), some aspects of cognitive dysfunction might even predate the

first episode, and thus serve as a predictive marker of depression. Compromised

performance on cognitive tests has been demonstrated three years before depression

develops (Airaksinen, Wahlin, Forsell, & Larsson, 2007) and with participants who are

not yet depressed but genetically at risk for depression (Mannie, Barnes, Bristow,

Harmer, & Cowen, 2009). Neuroanatomical abnormalities associated with recurrent

depression have been found in first episode MDD (Lee et al., 2012), further supporting

the hypothesis that some dysfunction may predate any potential long-term effects of

depression. Performance in a number of cognitive domains has proven stable over six

years for depressed patients (Sarapas, Shankman, Harrow, & Goldberg, 2012). It has

been suggested that cognitive impairment in affective disorders are the result of a trait-

level dysfunction in neural circuitry (Smith, Muir, & Blackwood, 2006; Thompson et

al., 2005). This could represent a stable and possibly heritable (Smith et al., 2006)

vulnerability to depression.

   A combination. The nature of the relationship between cognitive impairment

and depression could depend on several variables. One of these may be way in which

cognitive dysfunction is measured and defined. There are some indications that some

cognitive processes are only temporarily compromised in acute episodes, whereas

others might represent longer-lasting traits (Douglas & Porter, 2009; Huang, 2009; Lee

et al., 2012). In a meta-analysis of cognitive function in first episode MDD by Lee et al.

(2012), psychomotor speed and memory were described as state-dependent, whereas

attention and executive function were more persistent. This was also reported by

Douglas and Porter (2009). Huang (2009) has found poor executive and motor functioning to persist after remission, but not memory and attention.

The causality could also be reciprocal and complex. Longitudinal research reveals this complexity better than crossectional studies. For instance; cognitive measures at baseline predictive of psychosocial functioning 18 years later beyond the effect of illness severity (Sarapas et al., 2013), but cognitive functioning at 26 years was also strongly associated with average illness severity retrospectively (Sarapas et al., 2012). It thus seems that cognitive functioning at baseline might at least be predictive of a more debilitating form of depression. Regardless of the causal relationships, assessment of cognitive function may therefore be useful for early screening (Jaeger et al., 2006; Sarapas et al., 2012). It is possible that an initial cognitive vulnerability may be exacerbated by repeated depressive episodes. Understanding the causal relationship might also require taking into account shared influences, such as HPA-dysregulation (Arborelius et al., 1999; Schlosser et al., 2011).

Divergence due to Heterogeneity

One reason for the disagreements over the role of cognitive deficits in depression might be variations in methodology and the populations studied. Treating all MDD patients as one group has led to contradictory findings (Hammar & Årdal, 2009; McClintock, Husain, Greer, & Cullum, 2010). In order to further assess the independent impact of cognitive impairment, its effects needs to be differentiated from correlated characteristics of the illness, such as duration and number of episodes, depression subtype and other factors that have an impact on functioning (McIntyre et al., 2013). Numerous other variables have also been found to predict the degree to which cognitive impairment is associated with depression, such as comorbidity, age at onset, premorbid

intelligence and education level, current age, gender and profession (Elgamal et al., 2010; Gorwood et al., 2008; Grant, Thase, & Sweeney, 2001; Kessler, 2003; Levin, Heller, Mohanty, Herrington, & Miller, 2007; McIntyre et al., 2013). These variables have additionally been reported to interact; as with for instance cognitive flexibility, which correlated with more severe illness for unipolar but not bipolar depression (Sarapas et al., 2012). The present study used a well-defined population of outpatients experiencing first episode MDD with little or no co-morbidity. Even in well-defined populations, however, studying different parts of cognitive functioning, or using different tasks, might still lead to divergent conclusions on the role of cognitive impairment in depression (Jaeger et al., 2006). Identifying what tasks are sensitive to dysfunction in MDD is therefore essential.

Identifying which Specific Deficits are Associated with Depression

Attempting to describe the cognitive impairment more precisely has yielded widely varying results. Some of the domains that have been frequently linked to depression are: memory, problem solving, psychomotor speed and executive functions (Austin et al., 2001; Baune et al., 2014; Hammar & Årdal, 2009; Lee et al., 2012). However, in all these areas, studies are also reported which have found no impairment, and dividing each domain further into components such as working memory versus episodic memory, or cued versus free recall yields further discrepant findings (Austin et al., 2001; Baune et al., 2014; Hammar & Årdal, 2009; Lee et al., 2012). It might therefore be that crucial variables still remain unaccounted for in much of the previous literature that confound the question of which specific cognitive deficits are associated with depression. Characteristics of the study participants such as comorbidity, depression subtype, age, education, presence of psychosis, symptom severity and

medication have all been reported to influence what type of cognitive impairment that is found (Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lönnqvist, 2008; Hammar & Årdal, 2009; Jaeger et al., 2006; Kizilbash, Vanderploeg, & Curtiss, 2002; Lee et al., 2012; Levin et al., 2007), suggesting that various cognitive processes might be differentially associated with depression for dissimilar groups. Using small and differing test batteries may also make comparison between studies problematic, potentially leading to divergent conclusions (Jaeger et al., 2006).

Executive Functions

Despite these differences, there have also been frequent overlaps between findings. Executive functioning is one of the areas that have been often researched in relation to MDD, and results on a wide range of executive tasks have been associated with depression (Baune et al., 2010; Hammar & Årdal, 2009; Ottowitz, Dougherty, & Savage, 2002; Snyder, 2013; Stordal et al., 2004). The term *executive function* is used to describe higher-order cognitive control-mechanisms involved in the regulation of thought, emotion and behavior (Garavan, Ross, Murphy, Roche, & Stein, 2002; Miyake et al., 2000; Roth et al., 2005). Executive functions coordinate, monitor and modulate cognitive subprocesses to enable a flexible approach to varying demands and conditions (Miyake et al., 2000).

Examples of proposed executive function tasks include the ability to select and redirect attentional focus; make, select and switch strategies; monitor performance; utilize feedback; deploy cognitive resources efficiently; and inhibit inappropriate responses (P. Anderson, 2002; Baune et al., 2010; Ridderinkhof et al., 2004). Basic cognitive skills such as attention, memory, language and perception are utilized in order to produce complex, abstract and creative thought and behavior (Alvarez & Emory,

2006; Swanson, 2005), making executive functions essential parts of a wide range of

activities, including problem solving; decision making; goal-directed thought and

behavior; planning; and self-regulation (Miyake et al., 2000; Rose, Feldman, &

Jankowski, 2011; van der Plas, Crone, van den Wildenberg, Tranel, & Bechara, 2009).

When executive functions are operating successfully; thoughts, emotions and behaviors

are internally generated to a larger extent, and less stimulus-driven and automatic

(Miyake et al., 2000), allowing for our actions to be consistent with internal goals in a

complex and changing environment (Waskom et al., 2014).

In general, executive functions are thought to be specifically relevant in effortful

tasks that require novel or non-routine processing (Shallice, 1988), and when theres a

conflict between competing responses (Posner & DiGirolamo, 1998). It has therefore

been posited that they are especially important in less defined or constrained tasks,

where the participant needs to direct attention to relevant material and inhibit other

elements (Lezak, 1982).

Executive Functions and Research on Cognitive Impairment

Executive functions might be of particular interest when studying cognitive

impairment in MDD for a number of reasons. One reason is that executive functions are

likely to be important to a large number of tasks in everyday life as well as in controlled

settings (P. Anderson, 2002; Baune et al., 2010; Ridderinkhof, van den Wildenberg,

Segalowitz, & Carter, 2004; Waskom, Kumaran, Gordon, Rissman, & Wagner, 2014).

A deficit in this area is therefore plausible as an explanation for varied and numerous

problems. Hertel (1997) has suggested that the memory problems experienced in

depression are caused by poor cognitive control. Gotlib & Joormann (2010) ruled out

memory problems in one group of depressed individuals by structuring the task in a way

that reduced the opportunity for rumination; a process linked to executive control according to the authors. The fact that task characteristics, such as structure, have this impact on executive function performance could explain some of the variability previously discussed in cognitive function-results. It may be interesting to review the task structure in studies where results have contradicted many previous findings. For instance, in the study by Reischies and Neu (2000), in which illness duration or number of episodes did not correlate with cognitive dysfunction, the authors made a point of using short tasks.

Some cognitive function tasks might be placing greater demands on higher-level processes in charge of organizing and planning, in other words executive functions. In a review article, Castaneda et al. (2008) reported that in relation to depression, evidence of deficient executive functioning is more consistently found than problems with memory and learning. Comparisons of multiple tests in comprehensive test batteries have shown indications of executive dysfunction even when performance was unimpeded in a range of other domains (Hammar & Årdal, 2009; Porter, Gallagher, Thompson, & Young, 2003).

Executive Functions and Depression

Executive functioning has been liked to affective regulation and behavioral control (Gotlib & Joormann, 2010), and might consequently be a good candidate for exploring the relationship between cognition and affective disorders. The inability to disengage attention from negative material has been seen in depression (Beevers & Carver, 2003; Compton, Heller, Banich, Palmieri, & Miller, 2000), as have problems manipulating and discarding negative material from working memory (Gotlib &

Joormann, 2010). In people prone to rumination, impairments have been shown on tasks measuring executive function (Joormann & Gotlib, 2010).

Poor executive function might also be a good candidate for exploring disability in depression. Performance on tests of executive function has directly predicted daily functioning for a range of populations, including those with dysexecutive syndrome (Burgess, Alderman, Evans, Emslie, & Wilson, 1998), non-demented elderly people (Kiosses & Alexopoulos, 2005) and schizophrenia patients (Weinberger & Gallhofer, 1997). Executive functioning has also been found to predict important variables such as academic ability (Blair & Razza, 2007; Toll, Van der Ven, Kroesbergen, & Van Luit, 2011) and social skills (Hensler et al., 2014; Schonfeld, Paley, Frankel, & O'Connor, 2006).

Executive functions may prospectively influence affective adjustment; Ghassabian et al., (2014) found that executive functions mediated the link between low positive emotionality at 3 years of age, and withdrawn temperament at 6 years. Impaired executive functioning has additionally been evidenced in remission from affective symptoms, and is therefore a potential source of trait-like vulnerability or lasting disability (Bhardwaj et al., 2010; Douglas & Porter, 2009; Huang, 2009; Lee et al., 2012). It may be that not all patients with MDD suffer from executive dysfunction to an equal extent. According to a review by McIntyre et al. (2013), pronounced deficits in this area were present in about 20–30% of those with MDD.

Different Models of Executive Functions

The question of how cognitive functions are coordinated and selected has been approached from a variety of angles. Many models of various aspects of cognitive functioning have involved some form of control mechanism, such as Baddeley's *central*

executive for working memory (Baddeley, 1996); Posner and Petersen's top down

control of attention (Posner & Petersen, 1990); and Shallice and Norman's s*upervisory*

attentional system (Shallice & Norman, 1986) necessary for controlled, complex and

novel information processing. Even in more general conceptualizations, terminology

used as well as the importance awarded different control functions varies. Some have

argued for the primacy of goal-activation and maintenance (Duncan, Emslie, Williams,

Johnson, & Freer, 1996; Nieuwenhuis, Broerse, Nielen, & de Jong, 2004), the ability to

maintain an active representation of context information in working memory (Braver &

Cohen, 2001; Waskom et al., 2014) or navigating goals through a generalized cognitive

search process (Hills, Todd, & Goldstone, 2010). Regardless of what is considered the

main mechanism of executive control, it is clear that most researchers consider complex

cognitive operations to be dependent on some form of regulation and selection, whether

this is an emergent feature of the systems themselves or a separate process. The exact

operationalization of the term, including the number, nature and organization of these

executive functions, as well as the best way to assess them, varies somewhat in the

literature (Alvarez & Emory, 2006; Hammar & Årdal, 2009; Miyake et al., 2000).

One Executive Function

Some have argued for a unitary view of executive function, seeing it as a single

construct. Della Sala, Gray, Spinnler, and Trivelli (1998) asserted that the most

common neuropsychological tests all draw on a common resource, and that there is no

support for fractionation into subcategories of executive functions. De Frias, Dixon, and

Strauss (2006) found, using confirmatory factor analysis, that a single-factor structure of

executive functions provided the best fit. It has also been suggested that the proposed

functions of executive processes are better viewed as the outcome of other processes, such as working memory functioning (Kimberg, D'Esposito, & Farah, 1997).

Multiple Executive Functions

Most models, however, have posited a fragmentary view, consisting of distinct though often correlated mechanisms (P. Anderson, 2002; Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000; Stuss & Alexander, 2000). Although some executive functions have been found to depend on a general intelligence factor (Obonsawin et al., 2002), research has found that at least some functions (e.g. shifting and inhibition; Miyake et al., 2000) are independent of IQ. Ardila, Pineda, & Rosselli (2000) reject the correlation with traditional IQ measures altogether. Further support for the fractionation of executive functions comes from the fact that various pathologies have been associated with distinct executive functions (Ozonoff & Jensen, 1999; Pennington & Ozonoff, 1996) as well as variable developmental trajectories (P. Anderson, 2002). Behavioral symptoms of poor executive regulation have also been reported to load on multiple distinct factors (Burgess et al., 1998). Many of the tasks used to measure executive functions have been found to correlate with each other (Miyake et al., 2000; Della Sala et al., 1998), but these correlations have usually been low ($r = .40$ or less; Jurado & Rosselli, 2007).

Delis, Jacobson, Bondi, Hamilton, & Salmon (2003) have pointed out that in non-clinical populations, there tends to be a high degree of shared variance between tests of different cognitive functions, whereas the fragmentation becomes more apparent when comparing homogenous groups with focal neurological impairment to normative samples (Delis et al., 2003). There is still no consensus about the structure of executive

functions. Even if there are a number of subprocesses, these could still reflect different functions of one unitary system (Baddeley, 1996).

Measuring Executive Functions

Features of executive function make it a difficult domain to study. The extent to which a task requires deliberate and superordinate processes may vary between individuals and situations; even within a single test session performace on a given task can become increasingly automatized, and therefore less dependent on controlled processes (Hughes & Graham, 2002). Slight variations in task characteristics can shift the processing from automatic to controlled (Hughes & Graham, 2002). This can also potentially make repeated measures designs tricky, as a task is only new once (Hughes & Graham, 2002). Another potential obstable to repeated testing, and consequently to assessing the reliability of executive function task measures, is that complex tasks involving a number of processes are likely to result in more sources of variation, and therefore a higher chance of measurement error (Delis, Kramer, Kaplan & Holdnack, 2004). Establishing measures that are both complex and novel can thus come into conflict with the need for tests that are replicable and standardized. By definition, executive functions also integrate and depend on the intact operation of other cognitive domains, making it challenging to develop tasks with good discriminant validity, and to precisely describe the mechanisms of the executive functions (Alvarez & Emory, 2006; Jurado & Rosselli, 2007; Nieuwenhuis et al., 2004; Stuss & Alexander, 2000).

Real Life Implications of Executive Function Measurements

As discussed, assessment of executive functions involves measuring processes that are relevant to performance and self-regulation in a complex environment. This implies another inherent problem with measuring executive functions, as some

problems experienced in daily life may not be evident on structured laboratory tasks.

Simple, short tasks with explicit requirements ordered one at a time and initiated by the

experimenter do not require the same type of planning and organization of multiple

tasks over time that is needed in real life (Shallice & Burgess, 1991). The need for

testing procedures that replicate this element has been widely recognized (Goel,

Grafman, Tajik, Gana, & Danto, 1997; Levine, Dawson, Boutet, Schwartz, & Stuss,

2000; Shallice & Burgess, 1991; Wilson, 1993). Goel et al., (1997) found that patients

with frontal lobe damage performed adequately on specific, local tasks but were

impaired when the task required more global, higher-level structuring of the problem,

such as planning, shifting, allocating effort and generating feedback.

There have been numerous observations of inconsistencies between scores on

neuropsychological measures and difficulties in daily functioning (P. Anderson, 2002;

Levine et al., 2000; Toplak, West, & Stanovich, 2013). Naismith et al. (2007) found that

self-report and neuropsychological measures were concordant only for memory

performance, but not for speed, learning or executive functions. Daily functioning could

be influenced by compensatory strategies that are not available in the test situation, and

performance may depend on specific environmental demands (Chaytor & Schmitter-

Edgecombe, 2003). Chaytor, Schmitter-Edgecombe and Burr (2006) found that task

measures only predicted 18-20% of the variance in everyday life functioning for a group

of outpatients with various neurological conditions. This percentage was 51% when the

non-executive components e*nvironmental cognitive demand* and *compensatory strategy*

were added.

Other variables may also differentially inflluence performance in a testing

situaltion and the daily environment. For instance, tests done in ideal environments may

be less sensitive to effects of fatigue, distractions, emotions, and motivation; and high premorbid functioning and high IQ could mean that a large drop in daily functioning is experienced even with relatively small effects on specific tasks (Chaytor & Schmitter-Edgecombe, 2003).

The Components of Executive Function

Regardless of these difficulties with measurement, there is mounting evidence that a number of proposed subcategories of executive functions are useful to our understanding of cognitive mechanisms, behavior and performance. The most commonly cited executive functions are, according to Miyake et al. (2000): "Shifting between tasks or mental sets", "updating and monitoring of working memory representations" and, "inhibition of dominant or prepotent responses" (p.54).

Using confirmatory factor analysis they found the three factors; Shifting, Updating and Inhibition, to be moderately correlated but also distinguishable in tasks aimed at testing complex problem solving (Miyake et al., 2000). Thus, they concluded that although they may to a certain degree tap common resources or constitute aspects of a common construct, there is value in studying these elements separately when seeking to describe the mechanisms of executive function (Miyake et al., 2000). In a meta-analysis, Alvarez and Emory (2006) summarized previous findings and identified the factors constituting executive function as: "inhibition and switching", "working memory" and "sustained and selective attention" (p.17). As this article examines the role of inhibition, it is relevant to note that this construct is common to various models, and well established as an independent subprocess of executive functions.

Inhibition

Inhibition as an executive function refers to the capacity to overcome automatic, prepotent, routine, or dominant responses (Miyake et al., 2000; Shallice & Burgess, 1993; Shuster & Toplak, 2009). There are indications that inhibition could be valuable to understanding the relationship between affective symptoms, information processing and neurological impairments. In a recent review of the ways in which poor cognitive control causes a vulnerability to low affect (Joormann & Gotlib, 2010), inhibition had a central role. The authors suggested that the inability to disengage from, or inhibit, negative stimuli could be detrimental to the regulation of affect in multiple ways, leading to negatively biased appraisals and increased exposure to stressful stimuli (Gotlib & Joormann, 2010). Joormann and Gotlib (2010) reported that depression was associated with reduced inhibition of negative material. Furthermore, they found a correlation between emotion regulation strategies and inhibition (Joormann & Gotlib, 2010). Specifically, reduced inhibition was linked to more rumination, more expressive suppression and less reappraisal. Others have also linked impaired inhibition of negatively valenced material to depression (Goeleven, De Raedt, Baert, & Koster, 2006; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005). Impairment of inhibitory functions could therefore plausibly contribute to depression vulnerability.

It has further been suggested that inhibition has a central role in executive functioning. Inhibition has been found to correlate even with cognitive tests that were not viewed as executive function tasks, prompting Burgess et al. (1998) to suggest that this factor might be viewed as a «primary form of executive function» (p.555) that underlies problems on many other tests of cognitive functioning, and issues concerning social behavior, as well as being linked to the concept of general intelligence. A factor-

solution, highlighting the primacy of inhibition, was found when measuring every-day

dysexecutive symptoms in a non-clinical population (Chan, 2001). Others have also

suggested that the different executive functions require intact inhibition to operate

optimally (Barkley, 1997; Bull & Scerif, 2001; Diamond, Carlson, & Beck, 2005). This

could potentially explain the correlations between different executive functions (Bull &

Scerif, 2001). As previously mentioned, executive functions become especially relevant

in novel situations and in cognitive conflicts (Goel et al., 1997; Levine et al., 2000;

Lezak, 1982; Shallice & Burgess, 1991). Inhibition of the habitual, competing response

is therefore conceptually plausible as an essential part of cognitive control. Inhibition

has been shown to be one of the earliest executive functions to develop in children

(Jurado & Rosselli, 2007), so other capacities could theoretically build on the ability to

inhibit. The primary role of inhibition is not undisputed; it has for instance been

suggested that the purported effects of inhibition are better accounted for by differences

in processing speed or working memory (Conway & Engle, 1994; Salthouse & Meinz,

1995).

Inhibition in Daily Life

The previously discussed methodological issues concerning executive functions

in general are also significant obstacles to describing and operationalizing inhibition,

and subsequently determining what role it has in depression. As cognitive inhibition

cannot be observed directly, the presence and mechanisms of inhibition must be inferred

from behavior (Klein & Taylor, 1994). The types of tasks or behaviors used to define

the construct of inhibition have varied substantially, and there have been doubts about

the coherence of the inhibition construct across these different tasks and behaviors

(Klein & Taylor, 1994; Rabbit, 1997). MacLeod (2007) has suggested that a common

source of confusion in inhibition research is that "in cognition, inhibition is sometimes a measurable phenomenon, sometimes a theory about the cause of that phenomenon, and often both" (p.5). As discussed, much of the research into executive functions has used performance based measures, and the degree of overlap with behavior in daily life is not well established (MacLeod, 2007). Experienced problems with inhibitory control and impulsivity have been associated with deficits on many typical neurological tasks (Chan, 2001; Enticott, Ogloff, & Bradshaw, 2006; Fino et al., 2014; Posner et al., 2002), but there have also been a lot of contradictory findings (Mcauley, Chen, Goos, Schachar, & Crosbie, 2010; Samyn, Roeyers, Bijttebier, Rosseel, & Wiersema, 2015; Toplak et al., 2013).

Burgess et al. (1998) identified inhibition as a factor that accounted for symptoms of disinhibition on a behavioral level, as well as on a range of executive function tests. Zhou, Chen and Main (2012) have pointed out that the concept of inhibition in daily life has a lot in common with the temperamental dimension *effortful control,* which is often assessed using the same types of tasks (e.g. Stroop and Go/No-Go; Zhou et al., 2012). Effortful control involves self-regulation of emotion, thought and actions (Rothbart, Sheese, & Posner, 2007) and has been found to moderate the effects of negative or positive affect, rumination and depressive symptoms (Verstraeten, Vasey, Raes, & Bijttebier, 2009). Low effortful control has been reported to constitute a vulnerability to depression (Verstraeten et al., 2009). Zhou et al. (2012) identified inhibition, in addition to attentional control, as a central common characteristic that unites the terms *executive functions* and *effortful control* from cognitive neuroscience and personality/temperament perspectives respectively. However, they also point out the important distinction between them; where inhibition in the framework of effortful

control typically centers on emotional or motivational responses, the executive control paradigm typically assesses the inhibition of "cold" cognitive responses (Zhou et al., 2012). Blair and Razza (2007) have observed that while executive functions are usually thought of as volitional control mechanisms, effortful control often involves automatic or non-conscious regulation. They found that these two concepts were moderately correlated and accounted for distinct variance in children's academic ability (Blair & Razza, 2007). It is a possibility that this reflects a difference between the kinds of regulatory mechanisms that are relevant in daily life, and those that are needed for specific, limited tasks.

Multiple Inhibiting Processes

Nigg (2000) outlined eight different inhibitory functions grouped into *executive, motivational* and *automatic* processes. In his taxonomy, the Stroop task, similar to the CWIT in the present study (Delis, 2001), was classified as a measure of interference control (Nigg, 2000). Other common performance measures of inhibition, such as the Stop task and the Go/No-Go were regarded measures of *behavioral inhibition*, whereas suppressing irrelevant ideas and intrusive thoughts were considered examples of *cognitive inhibition* (Nigg, 2000). There were all under the umbrella of executive inhibition, while motivational inhibition effects denoted responses to punishment and novelty (Nigg, 2000). This is noteworthy as everyday life involves demands on inhibition in a variety of ways. Friedman and Miyake (2004), using structural equation modeling, found that they could separate two kinds of cognitive inhibition. One factor involved inhibiting prepotent responses as well as resisting distraction interference (Friedman & Miyake, 2004). This was related to problems such as everyday cognitive failures and task switching (Friedman & Miyake, 2004). The other factor consisted of

the ability to resist proactive interference and related to, amongst other things, resisting unwanted intrusive thoughts (Friedman & Miyake, 2004). Thus, the type inhibition task may affect the results in studies of inhibition, and tasks might need to be carefully selected based on the goals of the study. It remains to be established whether certain types of inhibition are more relevant to depression, and whether different forms of inhibition are differentially related to various aspects of depression such as regulation of affect, and disability.

Even on tasks apparently measuring very similar inhibition capacities, discrepancies in performance have been found. Khng and Lee (2014) compared the performance of adolescent pupils on two inhibition tasks that are both supposed to require inhibition of an inappropriate prepotent response, the Stroop task and the Stop-Signal task, and found no correlation. They also reported that they were associated with different neural substrates and developmental trajectories, affected clinical subgroups differently and loaded on different factors (Khng & Lee, 2014). Attempting to explain this discrepancy, they distinguished between inhibiting intrusion by recently learned responses, and intrusion by habitual responses, the former being related to general intelligence (Khng & Lee, 2009). In their account, the Stop-Signal task is among the tests that measure intrusion of recently learned material, whereas Stroop measures intrusion from more entrenched material (Khng & Lee, 2009), a distinction supported by other researchers as well (Bull & Scerif, 2001). The CWIT, at least the pure inhibition condition, is therefore according to this account presumably an example of inhibition of well-learned responses as it is similar to Stroop (Delis et al., 2001). If the different types of inhibition are fragmented in this way, the utility of any one type of measure in predicting functioning in another setting becomes questionable. It is possible

that these various forms of inhibition are manifestations of one core cognitive process, but this form of hierarchy has not been adequately described (MacLeod, 2007), and thus inferences about what tests better capture this hypothetical core process cannot be made.

Comparing Measures of Inhibition

Direct comparisons between self-reported inhibition on BRIEF-A and performance on the CWIT for depressed adults were not found, but limited research was available for other populations, and for the relationship between task and scale measures of executive functions more generally. Chaytor & Schmitter-Edgecombe (2003) reviewed six studies on the ecological validity of various executive functioning tests, and concluded that over all, they did not significantly correlate with self-report measures. Samyn et al. (2015) have suggested that the two types of measurement reflect different underlying constructs, as revealed by a latent-variable analysis of multiple task and scale measures of executive function, including inhibition. For an adult sample with mild to moderate traumatic brain injury, self-reported cognitive problems predicted some objective performance in attention/processing speed, but depressive symptomatology was a much better predictor of objective executive functioning than self-reports (Schiehser et al., 2011).

There are some studies that have compared the CWIT, or Stroop (similar to the CWIT; Delis et al., 2001) with scale rating measures other than BRIEF. For example Heflin et al. (2011), who found no correlation between Stroop results and a behavioral rating of disinhibition for patients with mild cognitive impairment or dementia. Chan (2001) found a barely significant ($p = .05$) and weak ($r = .18$) correlation between Stroop results and the factor Inhibition, created from responses to the Dysexecutive Questionnaire, amongst adults from the general population.

There have also been studies of the relationship of BRIEF-A and a variety of task measures. Toplak et al. (2013) reviewed thirteen different studies of patients with mild cognitive impairment or dementia that had compared BRIEF-A scores with various objective measures of executive functions. They found a median correlation of $r = .15$ for the various possible scale correlations, described by the authors as "extremely weak" (p.136). This was also the case for other rating scales; the Dysexecutive Questionnaire and scale measures of impulsivity, indicating that the problem here was not just with BRIEF (Toplak et al., 2013). Toplak et al. (2013) explained these findings by proposing that the measures pertain to different levels of cognitive control. According to the authors, everyday functioning, rated on scales such as BRIEF-A, is a matter of the *reflective mind* (Toplak et al., 2013). At the reflective level, thinking style, goals, beliefs and decisions play a large part (Stanovich, 2011; Toplak et al., 2013). Objective measures on the other hand, supposedly examine the relatively narrow functions at the level of the *algorithmic mind* (Toplak et al., 2013), which reflects the functional efficiency of the cognitive mechanisms (Stanovich, 2011). Stanovich (2011) has argued that constrained executive function tasks cannot assess strategic control processes, which occur at the level of the reflective mind. Toplak et al. (2013) also noted that a common methodological problem in studies comparing measures of executive function, including inhibition, is the use of multiple measures yielding a large number of correlations, of which only some are reported.

Relationship Between the CWIT and BRIEF-A

Of the studies reviewed by Toplak et al. (2013), only a few looked at both BRIEF and the CWIT. Parrish et al. (2007) reported correlations between parent-reported BRIEF scores and the CWIT, but in a sample of children with epilepsy. They

found that while both could distinguish the epilepsy from the non-epilepsy groups, the only correlation with CWIT was the Metacognition Index from BRIEF (Parrish et al., 2007). V. A. Anderson, P. Anderson, Northam, Jacobs and Mikiewicz (2002) found moderate positive correlations (from $r = .27$ to $r = .48$) between self-corrections on the Contingency Naming Task, a test similar to Stroop (Riddle & Suhr, 2012), and scores on BRIEF, particularly on scales belonging to the Metacognition Index. The population in this study was children with brain disease (V. A. Anderson et al., 2002). Shuster and Toplak (2009) reported a negative correlation ($r = -.32$, $p > .01$) between the Inhibit scale on BRIEF self-report and Stroop interference in a non-clinical population. This implies that more interference on Stroop was actually related to *fewer* self-reported difficulties on BRIEF (Shuster & Toplak, 2009). Post-hoc analyses revealed that the number of self-corrections positively correlated with Stroop interference score, but negatively with BRIEF scores (Shuster & Toplak, 2009). The authors suggest that self-corrections may be an example of something that contributes to good inhibition scores on self-reports but poor performance scores (Shuster & Toplak, 2009). They also found that performance measures of other types of inhibition significantly predicted responses on BRIEF independently of Stroop, suggesting the different measures might be assessing independent aspects of performance (Shuster & Toplak, 2009). Hummer et al. (2011) also reported a negative correlation between Stroop Interference and the Inhibit scale from BRIEF ($pr(35) = -0.37$, $p = .02$), when controlling for gender. Their sample consisted of adolescents that had attention deficit hyperactivity disorder (ADHD) and/or disruptive behviour disorders and healthy controls (Hummer et al., 2011).

In a study not included in the review by Toplak et al. (2013), Lalonde, Henry, Drouin-Germain, Nolin, and Beauchamp (2013) reported that amongst typically

developing adolescents, the CWIT did not predict results on parent-reported BRIEF. Interestingly, their virtual-reality version of the Stroop test did, however, leading the authors to suggest that it is a matter of ecological validity (Lalonde et al., 2013)

In summary, the reported correlations between BRIEF and the CWIT (or similar tasks) have been at best partial and moderate, and the direction of the relationship is inconsistent. Findings regarding the relationships between specific subscales on the two tests have also been inconsistent. The two kinds of test may be sensitive to different pathologies, as the discussed reseach has used widely varying populations. In the study by Samyn et al. (2015) only the objective measure was able to identify children with ADHD, or autism spectrum disorder. V. A. Anderson et al. (2002) found that the BRIEF-profile was distinct for children with focal frontal lesions when compared to more diffuse brain damage, whereas the objective measures could not. The correlation between the two types of measures might be determined in part by the clinical picture of the participants. It has been suggested that the correlation between task measures and daily problems may be higher for clinical populations, for whom the symptoms are more obvious, than for the general population (Chan, 2001). In line with this, Heinonen et al. (2013) found that BRIEF correlated with task measures of executive functions, including Stroop, for term-born control participants but not for very low birthweight adults. For the latter group, only parent ratings correlated with objective measures (Heinonen et al., 2013). With so many different populations and measures used, it's therefore not possible to draw any conclusions about adults with MDD. The fact that there have been reports of poor correspondence between tests, and differing underlying factor solutions, might indicate a need for a great degree of specificity when comparing findings.

The present study did focus on a specific group, MDD patients at one year after their first depressive episode. Previous studies of this sample by Schmid and Hammar (2013a, 2013b) have indicated that a deficit in cognitive inhibition as measured by the CWIT is present during first episode MDD and persists one year after initial diagnosis, despite symptom reduction (Schmid & Hammar, 2013b). The patients were particularly impaired on the inhibition condition with an added demand on cognitive flexibility (Inhibition/Switching; Schmid & Hammar, 2013b). Performance on the Inhibition/Switching condition was also worse at both testing times for the group that relapsed compared to those who did not (Schmid & Hammar, 2013b). There was no relationship between cognitive flexibility measured by other tasks and relapse or persistent impairment, suggesting inhibition is of primary interest (Schmid & Hammar, 2013b).

Groups that relapsed or experienced little or no change in their symptoms had a higher rating for illness severity at both testing times, but the effects of illness severity were controlled for when the relationship between cognitive function and relapse was assessed (Schmid & Hammar, 2013b). The correlation between illness severity and inhibition impairment was not significant, indicating that the impact of inhibition was not a result of illness severity (Schmid & Hammar, 2013b). Schmid & Hammar (2013b) also found that the slower reaction times on the inhibition task were not simply the result of lower processing speed.

The Current Study

The present study examined the relationship between self-reported and objective measures of inhibition at a one-year follow up of participants after they had presented with their first episode of depression. The goal was to investigate whether BRIEF-A

measures corroborated the results obtained using the CWIT which have indicated a lasting executive function deficit for previously depressed patients, especially in the area of inhibition (Schmid & Hammar, 2013b). Another objective was to see how the task measure of inhibition correlated with self reported general executive functioning and inhibition. I also wanted to know if the relationship between self-reported inhibition deficits and relapse was similar to that of task measured inhibition and relapse at follow up. Three questions were addressed:

1. Do participants diagnosed with MDD have a higher score on BRIEF-A than controls?

2. Do self-reported problems with general executive functioning, and cognitive inhibition specifically (BRIEF-A), correspond to the objective measure of cognitive inhibition (D-KEFS) for all groups?

3. Do those participants who experienced relapse within a year have a higher self-reported (BRIEF-A) deficit in inhibition than those who did not?

As previous analysis of the same participants using objective test measures have shown a persistent deficit in inhibition for the patient group (Schmid & Hammar, 2013b), it was expected that this would also be evident on self-report measures of the same cognitive construct. It was therefore hypothesized that the scores on BRIEF-A would be higher for depressed participants (Hypothesis 1) and that the two measures would be positively correlated (Hypothesis 2). Furthermore, a larger deficit in inhibition was detected amongst patients who experienced a relapse, both at initial testing and at a one-year follow-up. It was therefore hypothesized that patients who experienced a relapse would also have a higher score on self-reported inhibition problems as measured by BRIEF-A at one year follow up compared to those who did not relapse (Hypothesis 3).

Method

The current study is an extension of a larger longitudinal study of cognitive functioning in depression (Schmid and Hammar 2013a, 2013b). It is a crossectional analysis of data collected at a one-year follow-up. The participants have therefore been tested at two times, but the present analyses focused on the results from the second testing, a year after participants presented with their first depressive epidode. Results will be discussed in the context of previous findings using this sample.

Participants

Fifty-three participants (27 male, 26 female) between the ages of 20 and 42 ($M = 27.1$, $SD = 5.3$) were included in the analyses. They consisted of 26 patients who had met the criteria for MDD one year previously and 27 control subjects. See Table 1 for descriptive data. The participants included in this study were tested at two times; first at inclusion (T1), then one year later (T2). The present analysis concerns the results from T2, and used only those participants for whom the relevant data was available. This means that there were slightly fewer cases included in this analysis ($N = 53$) than at T1 ($N = 60$), due to dropout and lacking data.

Table 1

Descriptive data for the patient group and the control group at T2.

Variable	Patient group ($n = 26$)		Control group ($n = 27$)	
	M	SD	M	SD
Age	26.12	5.55	26.15	5.18
Education (years)	13.92	1.71	14.22	1.63
Males/females	13/13	-	13/14	-
MADRS score	9.72	5.54	-	-

Note. MADRS = Montgomery Åsberg Depression Rating Scale (Montgomery & Åsberg, 1979). MADRS scores not reported for healthy controls without symptoms of depression.

Inclusion. Inclusion criteria for the patient group at T1 was meeting the DSM-IV (2000) criteria for a unipolar first-episode MDD diagnosis, as assessed using the MINI-International Psychiatric Structural Interview (Leiknes, Leganger, Malt, & Malt, 1999). In addition, a minimum score of 20 on the Montgomery Åsberg Depression Rating Scale (MADRS), indicating a moderate to severe depression (Montgomery & Åsberg, 1979), was required. Patients who reported having previously experienced serious symptoms of depression, or who had been diagnosed with or treated for depression were excluded. As were patients with known brain damage, severe somatic disorders, alcohol and/or substance abuse, those who had been treated with electroconvulsive therapy, were psychotic or had experienced psychosis earlier in life.

Participants were recruited through primary health care. Doctors and psychologists informed patients about the study and determined who qualified for inclusion based on the criteria. The study coordinator then contacted those who were considered appropriate for inclusion and who consented to participate. At inclusion in the study, the MINI (Leiknes et al., 1999) was administered by a trained clinical psychologist in order to get a broad evaluation of psychiatric illnesses. Two patients reported symptoms of panic disorder, and met the criteria of a co-morbid diagnosis of panic disorder with agoraphobia.

All patients were outpatients. Some received either medical treatment (13.3%), psychological treatment (30%) or both (33.3%), and some (23.3%) received no treatment. Fourteen patients were prescribed antidepressant medication. Twelve patients were prescribed selective serotonin reuptake inhibitors (SSRIs; Cipralex, Citalopram); one used a serotonin noradrenaline reuptake inhibitor (SNRI; Effexor), and one used a tetracyclic antidepressant (TeCA; Remeron/Mirtazapine).

A control group (*n*=30) was matched to the patients at T1, based on gender, age and years of education (within a ±2 year limit). IQ scores were similar for the patient group (*M* = 118.53, *SD* = 8.12) and the control group (*M* = 120.97, *SD* = 8.23). Control participants were recruited from the University of Bergen and through acquaintances of employees of the Department of Biological and Medical Psychology of the University of Bergen. The controls were interviewed to rule out those who reported a history of mental disorder, brain damage, alcohol abuse or substance abuse.

Follow-up. At T2, one year later, the mean MADRS score for patient group was 9.72, indicating minimal symptoms of depression, and no need of treatment (Hawley et al., 2002). Of the 26 patients included in the present analysis, nine participants were using medication at T2, of which eight used SSRIs (Cipralex, Citalopram) and one used an SNRI (Venlafaxine).

At T2, the patients were grouped based on whether or not they had experienced a relapse since T1. The sample was therefore divided into a *relapse group* (*n* = 10), a *no relapse group* (*n* = 7) and a *no change group* (*n* = 2). The relapse and no relapse groups had a mean score on MADRS below 10, indicating that at the time of testing, depression severity for these groups was low and treatment not required (Hawley et al., 2002). The no change group reported experiencing their depression as more chronic, with short periods (lasting days or weeks) of minor symptoms. At follow-up, they had a mean MADRS score of 18, indicating a mild to moderate depression requiring treatment (Hawley et al., 2002). There were no major differences between the relapse group and the no relapse group regarding treatment variables across T1 and T2.

Measures

      The Delis-Kaplan Executive Function System. The participants were assessed using the The Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001) at T1 and T2. The D-KEFS is a neuropsychological battery made up of nine tests that can be used on their own or together with other parts of the set. It contains measures of verbal and non-verbal executive function, and assesses the function of more basic cognitive processes as well as executive functions, in order to distinguish the performance of each (Delis et al., 2001). A large number of studies with varied clinical populations have established that the D-KEFS tests are sensitive to impairements in executive functions and have adequate reliability compared to other executive measures (Delis et al., 2004).

      The Color Word Interference Test. The test from the D-KEFS that was used for analysis in in the present study was the Color Word Interference Test (CWIT). It is based on the classic Stroop test developed to study verbal interference effects (Delis et al., 2001). There have been numerous investigations of the reliability and validity of Stroop, showing good reliability and sensitivity to executive deficits, even though some practice effects have been reported (Homack & Riccio, 2004). The CWIT is intended to measure the ability to inhibit dominant, perserverative and impulsive verbal responses as well as requiring cognitive flexibility. It is made up of four conditions. In the Color Naming condition (C), the subject is presented with color patches and asked to name the color as fast as they can. In Word Reading (W), they are asked to read a word written in black, as fast as possible. The third condition, Color Word (CW), a measure of inhibition, is the classic Stroop condition, where participants are presented with color names written with different color fonts and asked to name the ink color. This requires

inhibition of word reading. In the fourth condition, Inhibition/Switching (IS), the subject has to switch between saying the color and reading the word depending on whether the word is in a frame, requiring set shifting as well as inhibition (Delis et al., 2001; Lippa & Davis, 2010; Swanson, 2005). The IS condition is assumed to be more difficult, although Lippa & Davis (2010) have shown that this is not always the case.

Faster reaction times on the CW and IS conditions are thought to reflect a better ability to inhibit interference and switch between mental sets (Delis et al., 2001).

The Behavior Rating Inventory of Executive Function—Adult Version. Participants were also given a Norwegian translation of the Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A; Nicholas & Solbakk, 2006). The adult version is based on the original BRIEF (Gioia, Isquith, Guy & Kenworthy, 2000), created to measure childrens' executive functioning as rated by their parents and teachers. The BRIEF-A contains a self-report form as well as an informant-report (Roth et al., 2005), but only the self-report was used in the current study to assess self-reported executive functioning in daily life.

The BRIEF-A self-report contains 75 items that assess the respondent on nine clinical scales and three validity scales. For each of the 75 items, the respondent marks whether they experience the statement as true *frequently, sometimes* or *never*. The nine clinical scales reflect distinct and empirically validated constructs that capture different facets of executive functioning. They are: *Inhibit*, *Shift* and *Emotional Control*, which grouped together are referred to as the *Behavioral Regulation Index*; and *Self Monitor Initiate*, *Working Memory*, *Plan/Organize*, *Task Monitor* and *Organization of Materials*, which make up the *Metacognition Index*. The overall summary score is the *Global Executive Composite (GEC)*. BRIEF-A has been used with a wide range of disorders to

assess executive functioning in adults between 18 and 90, and its reliability, validity and utility have been established empirically (Roth et al., 2005).

Inhibition. The Inhibit scale in BRIEF (Roth et al., 2005) consists of eight questions meant to capture «the ability to inhibit, resist or not act on impulse» (p.20). It can manifest as inappropriate, unsafe or disruptive behavior, a tendency to interrupt others and problems on delayed response tasks (Roth et al., 2005). Poor behavioral inhibition is often observed in ADHD and after traumatic brain injury (Roth et al., 2005). Some example questions from this scale are: item 16, «I have trouble sitting still»; item 43, «I make decisions that get me into trouble (legally, financially, socially)»; item 55, «People say that I am easily distracted» and item 73, «I am impulsive» (Roth et al., 2005).

The participants were also evaluated on a comprehensive test battery that included measures of IQ and other standardized experimental tests. They were not analyzed in the present study, but have been discussed previously (Schmid & Hammar, 2013a, 2013b).

Testing Procedure

Testing took place at the Institute of Biological and Medical Psychology, University of Bergen, Norway, and was administered by a trained senior test technician. The test technician was not blinded to which participants belonged to control group and which were patients, because of the nature of the recruitment procedure. Testing occurred in the same sequence for all participants, took about four hours to complete and was done during regular work-hours.

Ethical Considerations

The Regional Committee for Medical Research Ethics and The Norwegian Data Protection Authority has approved the study. The study was performed in accordance with the Helsinki Declaration of the World Medical Association Assembly. All participants gave their informed consent to participate at inclusion. The participants diagnosed with MDD were offered the normal treatment independently of the study.

Scoring and Data Analyses

For all analyses, raw scores were used. For both conditions on the CWIT, this consisted of the time taken to complete the tasks in seconds. For BRIEF, each item was converted to a score, with 1 corresponding to *Never,* 2 corresponding to *Sometimes* and 3 corresponding to *Often.* These were then summarized to produce the raw score. The statistical data analysis was done in the Statistical Package for the Social Sciences (SPSS) version 22. Effect sizes were calculated using the formula $r = z$ / square root of N.

Results

The data violated assumptions of normality. Kolmogorov-Smirnov and Levene's test were significant at the .01 level for the GEC and Inhibit scales of BRIEF-A. CWIT Condition 4 had a very high level of kurtosis (6.81) and high positive skewness (1.75). Non-parametric tests were used. The results for the three hypotheses are discussed in turn.

Hypothesis 1

The first hypothesis was that previously depressed participants would have a higher score on the Global Executive Composite (GEC) and Inhibit scales on BRIEF-A than controls. See Table 2 for an overview of the raw scores and T-scores.

A Mann-Whitney U test revealed significant differences between the patient group (*Md* = 116, *n* = 26) and the control group (*Md* = 79, *n* = 27) on the GEC, *U*= 39, *z* = -5.55, *p* =.00, *r* = - .76. There was also a significant difference between the patient group (*Md* = 11, *n* = 26) and the control group (Md = 9, *n* = 27) on the Inhibit subscale, *U* = 176, *z* = -3.164, *p* =.00, *r* = - .43.

Table 2

BRIEF-A and CWIT scores for the patient group and the control group at T2.

Score	Patient group (*n* = 26)		Control group (*n* = 27)	
	M	*SD*	*M*	*SD*
BRIEF-A GEC (raw)	119.19	23.58	81.74	10.89
BRIEF-A Inhibit (raw)	11.73	2.96	9.41	1.53
BRIEF-A GEC T-score	57.27	11.26	39.59	4.92
BRIEF-A Inhibit T-score	49.27	9.88	41.22	4.99
CWIT (CW)	47.62	1.33	41.70	1.31
CWIT (IS)	56.73	2.33	47.93	2.29

Note. GEC = Global Executive Composite. CWIT = Color Word Interference Test. CW = Color Word. IS = Inhibition/Switching. BRIEF-A T-scores ≥ 65 considered clinically significant. For T-scores, *M* = 50, *SD* = 10 (Roth et al., 2005).

A look at the T-scores of the two groups revealed that nine cases (34.6%) in the patient group, and none of the controls, had a GEC score of 65 or, the cutoff score for clinical significance (Roth et al., 2005).

Additional analyses of the change in BRIEF-A raw scores from T1 and T2 were done to assess the stability of these reported problems with inhibition and executive functioning across one year. T1 BRIEF-A data was only available for 31 cases, of which 18 were patients and 13 controls. A Wilcoxon Signed Rank Test revealed a statistically significant reduction in the GEC scores from T1 (*Md* = 94.00) to T2 (*Md* = 90), *z* = -2.11, *p* = .04, with a small to medium effect size (*r* = .27).

An examination of the subscales using the Wilcoxon Signed Rank Test revealed that the only significant change was on the scales that make up the Metacognition Index, $z = 3.18$, $p = .001$, which decreased from T1 ($Md = 53$) to T2 ($Md = 50$), with a large effect size ($r = .57$). Splitting the group into control and patients revealed that the change on the GEC measured by the Wilcoxon Signed Rank Test was significant for the patient group ($n = 13$), $z = -2.48$, $p = .013$ but not for the control group ($n = 18$), $z = -1.92$, $p = .05$. It is possible that splitting the groups this way resulted in insufficient power, as the total number of cases was only 31. These analyses of change scores constitute a tentative indication that scores on BRIEF-A were not completely stable after one year. It was only the scales subsumed by the Metacognition Index that changed significantly. It appears that the scores changed more for the patient group, but this is speculative, as there are probably too few data points to examine the statistical significance of this difference in change scores reliably.

The BRIEF-A Inhibit and GEC scores were compared with the depression symptoms, as measured on MADRS. Spearman's Rank Order Correlation revealed a significant correlation between the GEC and MADRS scores, $r = .63$, $n = 25$, $p = .001$. There was no significant correlation between MADRS scores and the BRIEF-A Inhibtion scale, $r = .312$, $n = 25$, $p = .13$

Hypothesis 2

The second hypothesis was that self-reported problems with cognitive inhibition (BRIEF-A) would correlate with the objective measure of cognitive inhibition (CWIT) for all groups.

The relationships between the Inhibit scale on BRIEF-A and reaction time on Condition 3 (Inhibit) and Condition 4 (Inhibit/switch) of the CWIT were investigated

using Spearman's Spearman's Rank Order Correlation. See Table 3 for correlations.

There was no significant correlation between the Inhibit scale and reaction time on

Condition 3, $r = .05$, $n = 53$, $p = .75$. There was also no correlation between the Inhibit

scale and Condition 4, r = .13, $n = 53$, $p = .35$. There was a significant positive

correlation of medium effect size between the GEC on BRIEF-A and condition 3, $r =$

$.30$, $n = 53$, $p = .03$. There was also a significant positive correlation between the GEC

and condition 4, $r = .37$, $n = 53$, $p = .006$. Adjusting for multiple correlations using a

Bonferroni correction, only the correlation between Condition 4 and the GEC were

significant at the required .01 level, indicating a positive correlation between the total

number of self-reported problems with executive functioning and longer reaction times

on the Inhibition/Switching condition of the CWIT.

Table 3

Correlations (Spearmans rho) between raw scores on the BRIEF-A and the CWIT for the whole sample (N = 53).

BRIEF-A Scale	Condition 3 (CW)	Condition 4 (IS)
GEC	.297[*]	.370[**]
Inhibit	.045	.132

Note. GEC = Global Executive Composite; CW = Color Word; IS = Inhibition Switching.
*p < 0.05 (2-tailed). **p < 0.01(2-tailed).

Hypothesis 3

The third hypothesis was that those participants who had relapsed within a year

would have a significantly higher self-reported (BRIEF-A) deficit in inhibition at T2

than those who didn't.

A Mann-Whitney U test revealed no significant differences between the relapse

group (*Md* = 133.5, $n = 10$) and the no relapse group (*Md* = 105, $n = 7$) on the GEC

scores, $U = 26$, $z = -.878$, $p = .42$. There was also no significant difference between the relapse group ($Md = 10.5$, $n = 10$) and the no relapse group ($Md = 12$, $n = 7$) on the Inhibit subscale, $U = 30$, $z = -.45$, $p = .67$. The low number of participants means there is a greater chance of type II error for this test.

In the relapse group, 50% had a GEC T-score above 65, in the no relapse group 28.6% had a GEC T-score of more than 65.

An exploration of the relationship between BRIEF-A scores at T1 and relapse was severely limited by the sample size, as BRIEF-A data was only available for five cases in the relapse group and three cases in the no relapse group at T1. For these, the difference between the relapse group ($Md = 115$, $n = 5$) and the no relapse group ($Md = 131$, $n = 3$) in T1 GEC scores was non-significant, $U = 5.5$, $z = -.60$, $p = .57$.

Discussion

The aim of this article was to examine persistent impairment of executive function, particularly inhibition, in first episode depression. Scores from the Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A) and the Color Word Interference Test (CWIT) from a one-year follow up were analyzed. The results supported a hypothesis of significantly elevated BRIEF-A scores for the patient group despite symptom remission, indicating persistent self-reported problems with inhibition and general executive functioning. This was consistent with findings of persistently impaired performance on the CWIT of inhibition in the same sample (Schmid & Hammar, 2013a). There were, however, significant differences between the two measures. There was some support for the hypothesis of a correlation between BRIEF-A and CWIT measures of executive function, but this was only the case for the BRIEF-A General Executive Composite (GEC) scale and the Inhibition/Switching (IS)

condition of the CWIT. There was no significant correlation of between the Inhibit scale on BRIEF-A and inhibition as measured by CWIT. There was no support for the hypothesis of a significant difference between the BRIEF-A scores of the relapse group and the no relapse groups, even though CWIT measured inhibition was persistently worse for the relapse group (Schmid & Hammar, 2013b). These findings will be discussed in turn.

Scores on BRIEF-A

There was support for the first hypothesis; the patient group reported significant problems with executive function, including inhibition, despite symptom remission. The effect size was large for the GEC and moderate for the Inhibit scale.

Some additional analyses were done to address the stability of the self-reported deficit, and the independence from affective symptoms. It was apparent that the scores decreased somewhat from T1 to T2, although the effect was small. It was also mainly the items subsumed by the Metacognition Index (MI) that improved. The MI score reflects the ability plan, organize and approach problems systematically and consists of five clinical scales that do not include Inhibit (Roth et al., 2005). The scores appeared to have improved more for the patient group, several of whom have gone from being in a depressive episode to no longer experiencing a depressive episode, although a larger data set is necessary to adequately investigate whether this group difference in change scores is significant. Some improvement has also been reported for CWIT scores (Schmid & Hammar, 2013b), with performance on the Color Word condition improving significantly for the no relapse group and Inhibition/Switching scores improving significantly for the control group.

There was a significant correlation between the patients' MADRS scores and GEC scores, but not the Inhibit scale. Despite the mean score for MADRS being at a level interpreted as remission (Hawley, Gale, & Sivakumaran, 2002), 10 out of 26 cases still had a score of 11 or above, indicating mild depression, and one case had a score of 22, just above the cutoff for moderate depression. This indicates that some influence of low-level residual symptoms on the GEC cannot be ruled out. It is also possible that persistent problems with executive functioning could lead to low-level symptoms associated with depression.

It was noted that nine of the patients, but none of the controls, had a BRIEF-A T-score of 65 or more, indicating clinically significant elevation (Roth et al., 2000). This allows for the possibility that a subset of MDD patients experience more significant problems with executive functions. McIntyre et al. (2013) suggested executive deficits were present in about 20-30% of depressed individuals. In this study, about 34.6% have clinically significant scores on BRIEF-A.

In summary, some of the self-reported problems with executive functioning in daily life appear to improve somewhat after symptom remission, but BRIEF-A scores for the patient group nonetheless remain significantly higher than for controls. Scores on the Inhibit scales are also significantly different for the patient and control groups, and appear to be more stable across one year. There is a significant correlation between the GEC scale and MADRS scores, but not the Inhibit scale and MADRS scores.

The Relationship between the BRIEF-A and the CWIT

There was partial support for the second hypothesis. There was no correlation between self-reported inhibition measured by BRIEF-A and inhibition as measured by the CWIT. There was, however, a significant correlation between the

Inhibition/Switching condition in the CWIT and the GEC in BRIEF-A. Before a

Bonferroni correction, the Inhibition condition was also significantly correlated with the

GEC. This suggests that self-reported executive functioning in general was correlated

with inhibition performance, but self-reported inhibition was not.

It is possible that with a larger sample, the Inhibit scale would also have reached

significance. The fact that the GEC, but not Inhibit, was correlated with MADRS score

could mean that the relationship between GEC score and CWIT performance was

somehow related to low level affective symptoms, even if there was no direct

correlation between CWIT and MADRS. It could also be that inaccurate self-perception

affects scores on the self-report measure. Alternatively, the results may reflect some real

difference between the underlying constructs being measured. If the results are

replicated in other samples, they may reflect a notable difference between the CWIT

and the BRIEF-A.

It could be argued that even the specific scales on BRIEF-A assess functioning

more broadly than the CWIT task. A number of variables, such as motivation, goals,

and situational variables may contribute to performance in a real world environment, as

pointed out by for example Chaytor et al., (2006). Items on the BRIEF-A Inhibit scale

refer to phenomena such as decisions, distractions and impulsivity, which all involve

interactions with the environment. Certain issues, such as "... trouble sitting still" (Roth

et al., 2005) are mostly noticeable in environments that demand specific behaviors.

Even if two individuals share a common cognitive deficit, this might therefore present

itself differently depending on their environment, resources and personality

characteristics. Different individuals may also utilize different compensatory

mechanisms (Chaytor et al., 2006). Some of these, such as self-correction (Shuster &

Toplak, 2009), may lead to slower reaction times on the CWIT but less apparent

inhibition problems in daily life. Thus it is possible that the CWIT and BRIEF-A are

sensitive to different manifestations of an inhibition deficit

It might also be that the two meausres do not measure the same underlying

cognitive mechanism. The validity of the inhibition construct is weakened if the

operationalization if the term depends on tests that do not correlate with each other. The

convergent validity of inhibition as measured by the different measures is debatable.

The discriminant validity of inhibition is called into question by the fact that the CWIT

measure of inhibition correlates more with general executive functions (GEC) than with

the Inhibit scale. Rabbitt (2004) has asserted that much of the divergence in the

executive function literature can be attributed to the fact that the study of executive

functions try to describe these functions at more than one level at once. He further

argues that the proposed components of executive functioning, including inhibition, are

actually just "descriptions of task demands" (p.1), and that performance on various

purported executive tasks may be excessively task-specific (Rabbitt, 2004).

The fact that it was only the combined Inhibition/Switching (IS) condition that

correlated with the GEC on BRIEF-A at a .01 level suggests that this condition might be

more strongly related to the experience of executive function in daily life. The unique

thing about this condition was the added demand of switching, or cognitive flexibility.

As other measures of cognitive flexibility were not correlated significantly with

depression in this sample (Schmid & Hammar, 2013a), it allows for the possibility that

the higher difficulty or complexity of the task is the factor that makes it more sensitive

to inhibition deficits than the pure inhibition condition (CW). As previously discussed,

task characteristics such as complexity and novelty may be crucial when assessing

executive functions (Goel et al., 1997; Levine et al., 2000; Shallice & Burgess, 1991). A

problem with this important aspect of the concept of executive functions is that novelty

and complexity are task characteristics that would probably also be more sensitive to

global reductions in processing efficiency (Rabbit, 2004). Based on the fact that

performance on other tasks requiring effortful processing are intact, Hammar et al. have

concluded that the observed impairments probably are not the result of higher demands.

Schmid & Hammar (2013b) also ruled out processing speed as an explanation of the

slower reaction times by subtracting the reaction times of the simple naming conditions

from the inhibition scores (calculationg the *contrast score*). There may still be other

variables that affect the performance on this measure preferentially, such as the ability

to learn from the preceding CW condition (Lippa & Davis, 2010).

It might also be the case that the mean performance on certain tests is not the

most informative metric. Nieuwenhuis et al. (2004), have suggested that variability in

performance between trials and between different tasks are more informative about

executive dysfunction than the group means for each trial or any specific task. They

have proposed that variability in performance can be elicited by variations in the task

characteristics; specifically whether features of the task encourage strategic attention to

demanding task characteristics and therefore encourage *goal activation* (Nieuwenhuis et

al. 2004). In other words, they propose a more general process rather than the operation

of specific executive domains to explain variability in results (Nieuwenhuis et al. 2004).

Another possibility is that instead of a different or more general mechanism,

more specificity is needed. These findings are consistent with propositions that there are

separate components of inhibition, allowing for the possibility that these two measures

tap into different components of the same umbrella term as suggested by a number of

previously discussed studies (Bull & Scerif, 2001; Friedman & Miyake, 2004; Khng &

Lee, 2009; Nigg, 2000).

Relapse and No Relapse Groups

No difference was found between those who had relapsed in the last year and

those who hadn't, however it is important to note that the number of participants for

which this data was presently available, was very low. With only seventeen cases, the

analysis might lack the statistical power to justify rejecting the hypothesis that those

who relapsed have more significant problems with self-reported inhibition. The median

score of the relapse group was slightly (though not significantly) higher than the no

relapse group, but the scores on inhibition were actually slightly (though not

significantly) lower for the relapse group. A larger sample is needed to examine whether

this reflects a real trend, or simply random variation as suggested by the present

analysis. If it really is the case that CWIT is correlated with the risk of relapse, but not

BRIEF-A, this is further reason to suggest there is some difference in the sensitivity of

the measures or in the underlying process that is assessed. Knowing which measures of

inhibition deficits are associated with risk of relapse could be valuable to developing

screening tools aimed at identifying at-risk groups.

Summary and Conclusions

These results added to previous findings of persistent executive function

impairments in first episode MDD by analyzing a self-report measure. Inhibition was of

particular interest, as this was the executive deficit most strongly related to depression

in previous studies (Schmid & Hammar, 2013a, 2013b). The relationship between the

inhibition scores on CWIT and BRIEF-A is ambiguous.

There was some congruence; both the CWIT and BRIEF-A inhibition scores seem to reveal relatively persistent and stable inhibition deficits, despite remission from MDD. Even though further analyses indicated a small significant decrease in the GEC score, especially for the patient group, this was apparently not the case for the Inhibit scale, suggesting its relative stability. The Inhibit scale was also not significantly correlated with concurrent depressive symptoms, and neither were the CWIT scores at T2 (Schmid & Hammar, 2013b)

Despite this, the direct correlation between the two measures of inhibition was not significant. CWIT was furthermore related to the risk of relapse, whereas there was no indication that BRIEF-A was. The large variations in previous research, as well as the low correlation between BRIEF-A and CWIT in the current study raises questions about the construct validity of inhibition as defined by these two measures.

Determining the cause of the discrepancy might provide valuable insights about cognitive funtioning in depression. Information about the patterns of impairment could perhaps be instrumental to expanding models of depression, or to identifying subgroups of MDD patients.

Limitations

A few methodological considerations impact the generalizability of these results. The inclusion criteria for participation were highly specific, with a relatively low age, no previous history of depression, outpatient status and little or no co-morbidity. While this is also one of the strengths of the study, the results may not extend to other groups. Some of the participants were receiving antidepressant medication and/or psychological treatment. Assessing the impact of these on BRIEF-A was beyond the scope of the present study, but CWIT scores did not appear to be affected by medication at follow-up

(Schmid & Hammar, 2013b). The average IQs of the patient (M = 118.53) and control

group (M = 120.97) as measured at T1 were quite high (Schmid & Hammar, 2013a).

Low sample sizes may have contributed to falsely accepting null-hypotheses,

particularly when comparing relapse groups. Low statistical power due to few

participants may also be one of the reasons why only one correlation between BRIEF-A

and CWIT reached significance.

Random sampling was not possible for this study. The control group was

matched on important characteristics, but it cannot be completely ruled out that there are

confounding variables not accounted for. Testing was not blinded.

It is not possible to draw conclusions about causality as it is a crossectional

study. The results do suggest that the cognitive impairment is not the result of long-term

depressive illness. In lieu of information about pre-morbid performance, however, it is

not possible to establish whether poor executive functioning, including inhibition,

contributed to the onset of depression, results from the first episode or is caused by

other variables. The positive correlation of MADRS scores with the BRIEF-A, but not

with CWIT, suggests that the former may be more closely linked to residual depressive

symptoms. The causal direction of this relationship is not possible to determine based

on the current study.

It cannot yet be determined with certainty that the measured impairments on

either measure really do reflect an underlying executive function or inhibition deficit in

the way it has been described in common models. The fact that only two different tests

of inhibition were analyzed limits any inferences about the underlying cognitive

constructs. Although there seems to be a variable that is affecting task performance on

the CWIT and executive function in daily life, it is still a matter of debate whether this

best explained by general or specific processes. The inherent problems with measuring

executive functions (e.g. Alvarez & Emory, 2006; Hughes & Graham, 2002; Jurado &

Rosselli, 2007; Nieuwenhuis et al., 2004; Stuss & Alexander, 2000) are relevant to the

current study. The participants had been tested on the same task measures twice,

although with one year in between sessions.

Implications and Future Research

The present findings corroborated previous results (Schmid & Hammar, 2013b)

suggesting that the inhibition problems in first episode MDD persist despite remission

from affective symptoms. This indicates the possibility of a trait-like vulnerability.

Follow-up studies after more than one year could answer whether cognitive function is

simply slower to normalize than affective symptoms, or if this impairment constitutes a

more permanent trait. Prospective studies with participants that have not previously

been depressed are needed in order to answer whether the deficit is present before the

first episode, occurs simultaneously with, or is a consequence of this first episode.

More research is needed to determine that the difference between control and

patient groups on BRIEF-A scores after remission are, like the CWIT scores (Schmid &

Hammar, 2013b), independent of the concurrent low-level depressive symptoms, as the

current analysis suggests a link between the BRIEF-A and MADRS scores. Similarly,

the work of ruling out other cognitive, affective and demographic third-variables

requires replication studies with various samples.

Correlations between the scale items and task performance were inconsistent, in

line with some previous findings (Mcauley et al., 2010; Samyn et al., 2015; & Toplak et

al., 2013), suggesting caution is needed when generalizing from performance on

specific task measures to daily life, and when comparing studies that have utilized

different forms of measurement. It could be that the two approaches are not interchangeable, but complimentary in capturing a broader picture of inhibition difficulties in MDD. More than one type of assessment may necessary to assess cognitive functions in depression, as suggested by Burgess (1998). Research with precisely defined populations and multiple types of measures could establish what impact specific deficits have on more general problem solving and daily situations.

Conceptual and methodological issues relating to executive function measurement in general, such as poorly defined and divergent descriptions of the various processes, and variable approaches to measurement (Rabbitt, 2004), need to be resolved before any conclusions can be drawn about the underlying constructs measured by the CWIT and BRIEF-A in MDD. The relationship between BRIEF-A and informant-reports on BRIEF-A, as well as other scale measures and objective measures of inhibition performance could provide valuable information.

It remains to be established whether various measures of inhibition are equally predictive of relapse. CWIT performance can be linked to the rate of relapse beyond what is explained by symptom severity (Schmid & Hammar, 2013b), but the present analyses could not determine reliably whether this was the case for BRIEF-A. Highly specific populations and thorough assessment of possible confounding variables are probably necessary in order to establish specific relationships between cognitive function measures and clinical features such as the risk of relapse.

Future studies may also reveal whether the pattern of impairment is specific to MDD. Multiple studies using various precisely defined populations could establish the specificity of this impairment. Research with other populations could furthermore decide if inhibition deficits are present for most of those who become depressed; or only

for some, as suggested by McIntyre et al. (2013). It could be that this impairment is associated with more severe subtypes of depression, or that it only constitutes a predisposition to depression in combination with other variables.

Determining whether there is a link between cognitive inhibition and vulnerability to depression is only the first step to developing interventions. If future research shows further support for a statistically and clinically significant effect of inhibition in predicting depressive episodes, the reasons for this need to be explored. Cognitive inhibition may impact mood and or general functioning directly (Gotlib & Joormann, 2010), but it could also be symptomatic of more severe depression subtypes, or of more important cognitive, clinical or environmental characteristics. If inhibition does have a causal role, the mechanisms though which this occurs, whether by affecting regulation of emotions, thoughts or behavior; or the ability to perform daily tasks, need to be described. Research on specific interventions is needed to test whether the impairment, or its effects on disability and the chance of experiencing depressive episodes, can be ameliorated. In addition to extending theories of cognitive impairment and developing targeted treatments, describing the patterns of impairment also has a more immediate application; if there are more chronic subtypes of depression associated with cognitive impairment, or certain groups that are at risk due to reduced cognitive performance, measures of cognitive functions could constitute a helpful tool in identifying these. Early interventions might then be developed with the aim of improving long-term outcomes and psychosocial functioning.

References

Adler, D. A., McLaughlin, T. J., Rogers, W. H., Chang, H., Lapitsky, L., & Lerner, D. (2006). Job performance deficits due to depression. *The American Journal of Psychiatry*, *163*(9), 1569–1576. doi:10.1176/appi.ajp.163.9.1569

Airaksinen, E., Wahlin, Å., Forsell, Y., & Larsson, M. (2007). Low episodic memory performance as a premorbid marker of depression: Evidence from a 3-year follow-up. *Acta Psychiatrica Scandinavica*, *115*(6), 458–465. doi:10.1111/j.1600-0447.2006.00932.x

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, *16*(1), 17–42. doi:10.1007/s11065-006-9002-x

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology*, *8*(2), 71–82. doi:10.1076/chin.8.2.71.8724

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Mikiewicz, O. (2002). Relationships between cognitive and behavioral measures of executive function in children with brain disease. *Child Neuropsychology*, *8*(4), 231–240. doi:10.1076/chin.8.4.231.13509

Arborelius, L., Owens, M. J., Plotsky, P. M., & Nemeroff, C. B. (1999). The role of corticotropin-releasing factor in depression and anxiety disorders. *The Journal of Endocrinology*, *160*(1), 1–12. doi:10.1677/joe.0.1600001

Ardila, A., Pineda, D., & Rosselli, M. (2000). Correlation between intelligence test scores and

    executive function measures. *Archives of Clinical Neuropsychology*, *15*(1), 31–36.

    doi:10.1016/S0887-6177(98)00159-0

Austin, M. P., Mitchell, P., & Goodwin, G. M. (2001). Cognitive deficits in depression:

    Possible implications for functional neuropathology. *The British Journal of Psychiatry*,

    178(3), 200–206. doi:10.1192/bjp.178.3.200

Baddeley, A. (1996). Exploring the central executive. *The Quarterly Journal of Experimental*

    Psychology Section A, *49*(1), 5–28. doi:10.1080/713755608

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions:

    Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94.

    doi:10.1037/0033-2909.121.1.65

Baune, B. T., Fuhr, M., Air, T., & Hering, C. (2014). Neuropsychological functioning in

    adolescents and young adults with major depressive disorder—A review. *Psychiatry*

    Research, *218*(3), 261–271. doi:10.1016/j.psychres.2014.04.052

Baune, B. T., Miller, R., McAfoose, J., Johnson, M., Quirk, F., & Mitchell, D. (2010). The role

    of cognitive impairment in general functioning in major depression. *Psychiatry*

    Research, *176*(2-3), 183–189. doi:10.1016/j.psychres.2008.12.001

Beevers, C. G., & Carver, C. S. (2003). Attentional bias and mood persistence as prospective

    predictors of dysphoria. *Cognitive Therapy and Research*, *27*(6), 619–637.

    doi:10.1023/A:1026347610928

Bhardwaj, A., Wilkinson, P., Srivastava, C., & Sharma, M. (2010). Cognitive deficits in

    euthymic patients with recurrent depression. *The Journal of Nervous and Mental*

    Disease, *198*(7), 513–515. doi:10.1097/NMD.0b013e3181e4c5ba

Biringer, E., Lundervold, A., Stordal, K., Mykletun, A., Egeland, J., Bottlender, R., & Lund, A. (2005). Executive function improvement upon remission of recurrent unipolar depression. *European Archives of Psychiatry and Clinical Neuroscience, 255*(6), 373–380. doi:10.1007/s00406-005-0577-7

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78*(2), 647–663. doi:10.1111/j.1467-8624.2007.01019.x

Boland, R. J., & Keller, M. B. (2009). Course and outcome of depression. In I. H. Gotlib & C. L. Hammen (Eds.), *Handbook of depression (2nd ed.)* (pp. 23–43). New York, NY: Guilford Press.

Bortolato, B., Carvalho, A. F., & McIntyre, R. S., (2014). Cognitive dysfunction in major depressive disorder: A state-of-the-art clinical review. *CNS & Neurological Disorders - Drug Targets (Formerly Current Drug Targets, 13*(10), 1804–1818. doi:10.2174/1871527313666141130203823

Braver, T. S., & Cohen, J. D. (2001). Working memory, cognitive control, and the prefrontal cortex: Computational and empirical studies. *Cognitive Processing, 2*(1), 25-55. Retrieved from http://ccpweb.wustl.edu/

Bromet, E., Andrade, L. H., Hwang, I., Sampson, N. A., Alonso, J., Girolamo, G. de, … Kessler, R. C. (2011). Cross-national epidemiology of DSM-IV major depressive episode. *BMC Medicine, 9*(1), 90. doi:10.1186/1741-7015-9-90

Buist-Bouwman, M. A., Ormel, J., De Graaf, R., De Jonge, P., Van Sonderen, E., Alonso, J., … the ESEMeD/MHEDEA 2000 investigators. (2008). Mediators of the association between depression and role functioning. *Acta Psychiatrica Scandinavica, 118*(6), 451–458. doi:10.1111/j.1600-0447.2008.01285.x

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology*, *19*(3), 273–293. doi:10.1207/S15326942DN1903_3

Burgess, P. W., Alderman, N., Evans, J., Emslie, H., & Wilson, B. A. (1998). The ecological validity of tests of executive function. *Journal of the International Neuropsychological Society*, 547–558. doi:10.1017/S1355617798466037

Castaneda, A. E., Tuulio-Henriksson, A., Marttunen, M., Suvisaari, J., & Lönnqvist, J. (2008). A review on cognitive impairments in depressive and anxiety disorders with a focus on young adults. *Journal of Affective Disorders*, *106*(1–2), 1–27. doi:10.1016/j.jad.2007.06.006

Chan, R. C. K. (2001). Dysexecutive symptoms among a non-clinical sample: A study with the use of the Dysexecutive Questionnaire. *British Journal of Psychology 92*(3), 551–565. doi: 10.1348/000712601162338

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. *Neuropsychology Review*, *13*(4), 181–197.

Chaytor, N., Schmitter-Edgecombe, M., & Burr, R. (2006). Improving the ecological validity of executive functioning assessment. *Archives of Clinical Neuropsychology*, *21*(3), 217–227. doi:10.1016/j.acn.2005.12.002

Clark, L., Iversen, S. D., & Goodwin, G. M. (2002). Sustained attention deficit in bipolar disorder. *The British Journal of Psychiatry*, *180*(4), 313–319. doi:10.1192/bjp.180.4.313

Compton, R. J., Heller, W., Banich, M. T., Palmieri, P. A., & Miller, G. A. (2000). Responding to threat: Hemispheric asymmetries and interhemispheric division of input. *Neuropsychology*, *14*(2), 254–264. doi:10.1037/0894-4105.14.2.254

Conway, A. R., & Engle, R. W. (1994). Working memory and retrieval: A resource-dependent inhibition model. *Journal of Experimental Psychology. General*, *123*(4), 354–373. doi:10.1037/0096-3445.123.4.354

De Frias, C. M., Dixon, R. A., & Strauss, E. (2006). Structure of four executive functioning tests in healthy older adults. *Neuropsychology*, *20*(2), 206–214. doi:10.1037/0894-4105.20.2.206

Delis, D. C., Jacobson, M., Bondi, M. W., Hamilton, J. M., & Salmon, D. P. (2003). The myth of testing construct validity using factor analysis or correlations with normal or mixed clinical populations: Lessons from memory assessment. *Journal of the International Neuropsychological Society: JINS*, *9*(6), 936–946. doi:10.1017/S1355617703960139

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System (D-KEFS) examiner's manual*. San Antonio, TX: The Psychological Corporation.

Delis, D.,C., Kramer J.,H., Kaplan, E., & Holdnack, J. (2004). Reliability and validity of the Delis-Kaplan Executive Function System: An update. *Journal of the International Neuropsychological Society*, *10*, 301-303. doi:10.1017/S1355617704102191

Della Sala, S., Gray, C., Spinnler, H., & Trivelli, C. (1998). Frontal lobe functioning in man: The riddle revisited. *Archives of Clinical Neuropsychology*, *13*(8), 663–682. doi:10.1093/arclin/13.8.663

Diamond, A., Carlson, S. M., & Beck, D. M. (2005). Preschool children's performance in task switching on the dimensional change card sort task: Separating the dimensions aids the

ability to switch. *Developmental Neuropsychology*, *28*(2), 689–729.

doi:10.1207/s15326942dn2802_7

Douglas, K. M., & Porter, R. J. (2009). Longitudinal assessment of neuropsychological

function in major depression. *The Australian and New Zealand Journal of Psychiatry*,

43(12), 1105–1117. doi:10.3109/00048670903279887

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the

frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology*, *30*(3),

257–303. doi:10.1006/cogp.1996.0008

Elgamal, S., Denburg, S., Marriott, M., & MacQueen, G. (2010). Clinical factors that predict

cognitive function in patients with major depression. *Canadian Journal of Psychiatry.*

Revue Canadienne De Psychiatrie, *55*(10), 653–661. Retrieved from ProQuest Research

Library http://search.proquest.com/docview/761000188/fulltextPDF

Enticott, P. G., Ogloff, J. R. P., & Bradshaw, J. L. (2006). Associations between laboratory

measures of executive inhibitory control and self-reported impulsivity. *Personality and*

Individual Differences, *41*(2), 285–294. doi:10.1016/j.paid.2006.01.011

Ferrari, A. J., Charlson, F. J., Norman, R. E., Patten, S. B., Freedman, G., Murray, C. J. L., …

Whiteford, H. A. (2013). Burden of depressive disorders by country, sex, age, and year:

Findings from the global burden of disease study 2010. *PLoS Med*, *10*(11), e1001547.

doi:10.1371/journal.pmed.1001547

Fino, E., Melogno, S., Iliceto, P., D'Aliesio, S., Pinto, M. A., Candilera, G., & Sabatello, U.

(2014). Executive functions, impulsivity, and inhibitory control in adolescents: A

structural equation model. *Advances in Cognitive Psychology, 10*(2), 32–38.

doi:10.5709/acp-0154-5

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control

  functions: A latent-variable analysis. *Journal of Experimental Psychology: General*,

  133(1), 101–135. doi:10.1037/0096-3445.133.1.101

Garavan, H., Ross, T. J., Murphy, K., Roche, R. A. P., & Stein, E. A. (2002). Dissociable

  executive functions in the dynamic control of behavior: Inhibition, error detection, and

  correction. *NeuroImage*, *17*(4), 1820–1829. doi:10.1006/nimg.2002.1326

Ghassabian, A., Szekely, E., Herba, C. M., Jaddoe, V. W., Hofman, A., Oldehinkel, A. J., …

  Tiemeier, H. (2014). From positive emotionality to internalizing problems: The role of

  executive functioning in preschoolers. *European Child & Adolescent Psychiatry*, *23*(9),

  729–741. doi:10.1007/s00787-014-0542-y

Gillespie, C. F., & Nemeroff, C. B. (2005). Hypercortisolemia and depression. *Psychosomatic*

  Medicine, *67*(1), 26–28. doi:10.1097/01.psy.0000163456.22154.d2

Gioia, G. A, Isquith, P. K, Guy, S. C, & Kenworthy, L (2000). *BRIEF—Behavior Rating*

  Inventory of Executive Function. Lutz, FL: Psychological Assessment Resources PAR.

Goeleven, E., De Raedt, R., Baert, S., & Koster, E. H. W. (2006). Deficient inhibition of

  emotional information in depression. *Journal of Affective Disorders*, *93*(1–3), 149–157.

  doi:10.1016/j.jad.2006.03.007

Goel, V., Grafman, J., Tajik, J., Gana, S., & Danto, D. (1997). A study of the performance of

  patients with frontal lobe lesions in a financial planning task. *Brain*, *120*(10), 1805–

  1822. doi:10.1093/brain/120.10.1805

Gorwood, P., Corruble, E., Falissard, B., & Goodwin, G. M. (2008). Toxic effects of

  depression on brain function: Impairment of delayed recall and the cumulative length of

  depressive disorder in a large sample of depressed outpatients. *The American Journal of*

  Psychiatry, *165*(6), 731–739. doi:10.1176/appi.ajp.2008.07040574

Gostautas, A., Pranckeviciene, A., & Matoniene, V. (2006). Changes in depression and quality

of life during inpatient treatment of depression. *Medicina (Kaunas, Lithuania)*, *42*(6),

472–478. Retrieved from http://medicina.lsmuni.lt/

Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: current status and future

directions. *Annual Review of Clinical Psychology*, *6*, 285–312.

doi:10.1146/annurev.clinpsy.121208.131305

Grant, M. M., Thase, M. E., & Sweeney, J. A. (2001). Cognitive disturbance in outpatient

depressed younger adults: Evidence of modest impairment. *Biological Psychiatry*,

50(1), 35–43. doi:10.1016/S0006-3223(00)01072-6

Hammar, Å., Strand, M., Årdal, G., Schmid, M., Lund, A., & Elliott, R. (2011). Testing the

cognitive effort hypothesis of cognitive impairment in major depression. *Nordic Journal

of Psychiatry*, 65 (1), 74– 80. doi:10.3109/08039488.2010.494311

Hammar, Å., & Årdal, G., (2009). Cognitive functioning in major depression – A summary.

Frontiers in Human Neuroscience, *3*. 26. doi:10.3389/neuro.09.026.2009

Hawley, C. J., Gale, T. M., & Sivakumaran, T. (2002). Defining remission by cut off score on

the MADRS: Selecting the optimal value. *Journal of Affective Disorders*, *72*(2), 177–

184. doi:10.1016/S0165-0327(01)00451-7

Heflin, L. H., Laluz, V., Jang, J., Ketelle, R., Miller, B. L., & Kramer, J. H. (2011). Let's

inhibit our excitement: The relationships between stroop, behavioral disinhibition, and

the frontal lobes. *Neuropsychology*, *25*(5), 655–665. doi:10.1037/a0023863

Heinonen, K., Pesonen, A.-K., Lahti, J., Pyhälä, R., Strang-Karlsson, S., Hovi, P., …

Raikkonen, K. (2013). Self- and parent-rated executive functioning in young adults with

very low birth weight. *Pediatrics*, *131*(1), 243-250. doi:10.1542/peds.2012-0839

Hensler, M., Wolfe, K., Lebensburger, J., Nieman, J., Barnes, M., Nolan, W., … Madan-Swain, A. (2014). Social skills and executive function among youth with sickle cell disease: A preliminary investigation. *Journal of Pediatric Psychology*, *39*(5), 493–500. doi:10.1093/jpepsy/jst138

Herbert, J., Goodyer, I. M., Grossman, A. B., Hastings, M. H., de Kloet, E. R., Lightman, S. L., … Seckl, J. R. (2006). Do corticosteroids damage the brain? *Journal of Neuroendocrinology*, *18*(6), 393–411. doi:10.1111/j.1365-2826.2006.01429.x

Hertel, P. T. (1997). On the contributions of deficent cognitive control to memory impairments in depression. *Cognition and Emotion*, *11*(5-6), 569–583. doi:10.1080/026999397379890a

Hills, T. T., Todd, P. M., & Goldstone, R. L. (2010). The central executive as a search process: priming exploration and exploitation across domains. *Journal of Experimental Psychology: General*, *139*(4), 590–609. doi:10.1037/a0020666

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. doi:/10.1016/j.acn.2003.09.003

Huang, C. L.-C. (2009). Residual cognitive deficit in adults with depression who recovered after 6-month treatment: Stable versus state-dependent markers. *Journal of Clinical Medicine Research*, *1*(4), 202–206. doi:10.4021/jocmr2009.10.1266

Hughes, C., & Graham, A. (2002). Measuring executive functions in childhood: Problems and solutions? *Child and Adolescent Mental Health*, *7*(3), 131–142. doi:10.1111/1475-3588.00024

Hummer, T. A., Kronenberger, W. G., Wang, Y., Dunn, D. W., Mosier, K. M., Kalnin, A. J., & Mathews, V. P. (2011). Executive functioning characteristics associated with ADHD

comorbidity in adolescents with disruptive behavior disorders. *Journal of Abnormal Child Psychology*, *39*(1), 11–19. doi:10.1007/s10802-010-9449-3

Ingram, R. E. (2003). Origins of cognitive vulnerability to depression. *Cognitive Therapy and Research*, *27*(1), 77–88. doi:10.1023/A:1022590730752

Jaeger, J., Berns, S., Uzelac, S., & Davis-Conway, S. (2006). Neurocognitive deficits and disability in major depressive disorder. *Psychiatry Research*, *145*(1), 39–48. doi:10.1016/j.psychres.2005.11.011

Joormann, J., & Gotlib, I. H. (2010). Emotion regulation in depression: Relation to cognitive inhibition. *Cognition & Emotion*, *24*(2), 281–298. doi:10.1080/02699930903407948

Judd, L. L., Paulus, M. P., Wells, K. B., & Rapaport, M. H. (1996). Socioeconomic burden of subsyndromal depressive symptoms and major depression in a sample of the general population. *The American Journal of Psychiatry*, *153*(11), 1411–1417. doi:10.1176/ajp.153.11.1411

Jurado, M. B., & Rosselli, M. (2007). The Elusive nature of executive functions: A review of our current understanding. *Neuropsychological Review*, 213–233. doi:10.1007/s11065-007-9040-z

Kessing, L. V. (1998). Cognitive impairment in the euthymic phase of affective disorder. *Psychological Medicine*, *28*(5), 1027–1038. doi:10.1017/S104161020600319X

Kessler, R. C. (2003). Epidemiology of women and depression. *Journal of Affective Disorders*, *74*(1), 5–13. doi:10.1016/S0165-0327(02)00426-3

Khng, K. H., & Lee, K. (2009). Inhibiting interference from prior knowledge: Arithmetic intrusions in algebra word problem solving. *Learning and Individual Differences*, *19*(2), 262–268. doi:10.1016/j.lindif.2009.01.004

Khng, K. H., & Lee, K. (2014). The relationship between stroop and stop-signal measures of

inhibition in adolescents: Influences from variations in context and measure estimation.

PLoS ONE, 9(7), e101356. doi:10.1371/journal.pone.0101356

Kimberg, D. Y., D'Esposito, M., & Farah, M. J. (1997). Cognitive functions in the prefrontal

cortex: Working memory and executive control. *Current Directions in Psychological

Science, 6*(6), 185–192. 10.1111/1467-8721.ep10772959

Kiosses, D. N., & Alexopoulos, G. S. (2005). IADL functions, cognitive deficits, and severity

of depression: A preliminary study. *The American Journal of Geriatric Psychiatry:

Official Journal of the American Association for Geriatric Psychiatry, 13*(3), 244–249.

doi:10.1176/appi.ajgp.13.3.244

Kizilbash, A. H., Vanderploeg, R. D., & Curtiss, G. (2002). The effects of depression and

anxiety on memory performance. *Archives of Clinical Neuropsychology, 17*(1), 57–67.

doi:10.1016/S0887-6177(00)00101-3

Klein, R. M., & Taylor, T. L. (1994). Categories of cognitive inhibition with reference to

attention. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention,

memory, and language* (pp. 113-150). San Diego, CA: Academic Press.

Koster, E. H. W., De Raedt, R., Goeleven, E., Franck, E., & Crombez, G. (2005). Mood-

congruent attentional bias in dysphoria: Maintained attention to and impaired

disengagement from negative information. *Emotion, 5*(4), 446–455. doi:10.1037/1528-

3542.5.4.446

Lalonde, G., Henry, M., Drouin-Germain, A., Nolin, P., & Beauchamp, M. H. (2013).

Assessment of executive function in adolescence: A comparison of traditional and

virtual reality tools. *Journal of Neuroscience Methods, 219*(1), 76–82.

doi:10.1016/j.jneumeth.2013.07.005

Lee, R. S. C., Hermens, D. F., Porter, M. A., & Redoblado-Hodge, M. A. (2012). A meta-

analysis of cognitive deficits in first-episode major depressive disorder. *Journal of

Affective Disorders*, *140*(2), 113–124. doi:10.1016/j.jad.2011.10.023

Leiknes, K. A., Leganger, S., Malt, E. A., & Malt, U. (1999). Mini internasjonalt

neuropsykiatrisk intervju. In D. Sheehan, J. Janavs, J. Baker, K. Harnett-Sheenan, E.

Knapp, & M. Sheehan (Eds.), *Mini international neuropsychiatric interview*. Tampa,

FL: University of South Florida.

Lehto, J. E., Juujarvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive

functioning: Evidence from children. *The British Journal of Developmental Psychology*,

21, 59. doi:10.1348/026151003321164627

Lépine, J.,P., & Briley, M. (2011). The increasing burden of depression. *Neuropsychiatric

Disease and Treatment*, *7*(Suppl. 1), 3–7. doi:10.2147/NDT.S19617

Levine, B., Dawson, D., Boutet, I., Schwartz, M. L., & Stuss, D. T. (2000). Assessment of

strategic self-regulation in traumatic brain injury: Its relationship to injury severity and

psychosocial outcome. *Neuropsychology*, *14*(4), 491–500. doi:10.1037/0894-

4105.14.4.491

Levin, R. L., Heller, W., Mohanty, A., Herrington, J. D., & Miller, G. A. (2007). Cognitive

deficits in depression and functional specificity of regional brain activity. *Cognitive

Therapy and Research*, *31*(2), 211–233. doi:10.1007/s10608-007-9128-z

Lezak, M. D. (1982). The problem of assessing executive functions. *International Journal of

Psychology*, *17*(1-4), 281–297. doi:10.1080/00207598208247445

Lippa, S. M., & Davis, R. N. (2010). Inhibition/switching is not necessarily harder than

inhibition: An analysis of the D-KEFS Color Word Interference Test. *Archives of

Clinical Neuropsychology, 25*(2), 146-152. doi:10.1093/arclin/acq001

MacLeod, C. M. (2007). The concept of inhibition in cognition. In D. S. Gorfein & C. M.

MacLeod (Eds.), *Inhibition in cognition* (pp. 3–23). Washington, DC: American

Psychological Association.

Mannie, Z. N., Barnes, J., Bristow, G. C., Harmer, C. J., & Cowen, P. J. (2009). Memory

impairment in young women at increased risk of depression: influence of cortisol and 5-

HTT genotype. *Psychological Medicine*, *39*(05), 757–762.

doi:10.1017/S0033291708004248

Mathews, A., & MacLeod, C. (2005). Cognitive vulnerability to emotional disorders. *Annual

Review of Clinical Psychology*, *1*, 167–195.

doi:10.1146/annurev.clinpsy.1.102803.143916

Mcauley, T., Chen, S., Goos, L., Schachar, R., & Crosbie, J. (2010). Is the Behavior Rating

Inventory of Executive Function more strongly associated with measures of impairment

or executive function? *Journal of the International Neuropsychological Society*, *16*(03),

495–505. doi:10.1017/S1355617710000093

McClintock, S. M., Husain, M. M., Greer, T. L., & Cullum, C. M. (2010). Association between

depression severity and neurocognitive function in major depressive disorder: A review

and synthesis. *Neuropsychology*, *24*(1), 9–34. doi:10.1037/a0017336

McIntyre, R. S., Cha, D. S., Soczynska, J. K., Woldeyohannes, H. O., Gallaugher, L. A.,

Kudlow, P., … Baskaran, A. (2013). Cognitive deficits and functional outcomes in

major depressive disorder: Determinants, substrates, and treatment interventions.

Depression and Anxiety, *30*(6), 515–527. doi:10.1002/da.22063

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D.

(2000). The unity and diversity of executive functions and their contributions to

complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. doi:10.1006/cogp.1999.0734

Montgomery, S. A., & Åsberg, M. (1979). A new depression scale designed to be sensitive to change. *British Journal of Psychiatry*, *134,* 322-389.

Mueller, T. I., Leon, A. C., Keller, M. B., Solomon, D. A., Endicott, J., Coryell, W., … Maser, J. D. (1999). Recurrence after recovery from major depressive disorder during 15 years of observational follow-up. *The American Journal of Psychiatry*, *156*(7), 1000–1006. Retrieved from ProQuest Research Library

http://search.proquest.com/docview/220490647?accountid=8579

Naismith, S. L., Longley, W. A., Scott, E. M., & Hickie, I. B. (2007). Disability in major depression related to self-rated and objectively-measured cognitive deficits: A preliminary study. *BMC Psychiatry*, *7*(1), 32. doi:10.1186/1471-244X-7-32

Nemeroff, C. B. (1988). The role of corticotropin-releasing factor in the pathogenesis of major depression. *Pharmacopsychiatry*, *21*(2), 76–82. doi:10.1055/s-2007-1014652

Neu, P., Bajbouj, M., Schilling, A., Godemann, F., Berman, R. M., & Schlattmann, P. (2005). Cognitive function over the treatment course of depression in middle-aged patients: Correlation with brain MRI signal hyperintensities. *Journal of Psychiatric Research*, *39*(2), 129–135. doi:10.1016/j.jpsychires.2004.06.004

Nicholas, J., & Solbakk, A.K. (2006). *Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A)*. [Norwegian translation with permission from Roth, Isquith, & Gioia (2005)]. Stockholm, Sweden: Hogrefe Psykologiförlaget.

Nieuwenhuis, S., Broerse, A., Nielen, M. M. A., & de Jong, R. (2004). A goal activation approach to the study of executive function: An application to antisaccade tasks. *Brain and Cognition*, *56*(2), 198–214. doi:10.1016/j.bandc.2003.12.002

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin*, *126*(2), 220–246. doi:10.1037/0033-2909.126.2.220

Obonsawin, M. C., Crawford, J. R., Page, J., Chalmers, P., Cochrane, R., & Low, G. (2002). Performance on tests of frontal lobe function reflect general intellectual ability. *Neuropsychologia*, *40*(7), 970–977. doi:10.1016/S0028-3932(01)00171-3

Ottowitz, W. E., Dougherty, D. D., & Savage, C. R. (2002). The neural network basis for abnormalities of attention and executive function in major depressive disorder: implications for application of the medical disease model to psychiatric disorders. *Harvard Review of Psychiatry*, *10*(2), 86–99. doi:10.1080/10673220216210

Ozonoff, S., & Jensen, J. (1999). Brief report: Specific executive function profiles in three neurodevelopmental disorders. *Journal of Autism and Developmental Disorders*, *29*(2), 171–177. doi:10.1023/A:1023052913110

Papakostas, G. I. (2014). Cognitive symptoms in patients with major depressive disorder and their implications for clinical practice. *The Journal of Clinical Psychiatry*, *75*(1), 8–14. doi:10.4088/JCP.13r08710

Parrish, J., Geary, E., Jones, J., Seth, R., Hermann, B., & Seidenberg, M. (2007). Executive functioning in childhood epilepsy: Parent-report and cognitive assessment. *Developmental Medicine & Child Neurology*, *49*(6), 412–416. doi:10.1111/j.1469-8749.2007.00412.x

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *37*(1), 51–87. doi:10.1111/j.1469-7610.1996.tb01380.x

Porter, R. J., Gallagher, P., Thompson, J. M., & Young, A. H. (2003). Neurocognitive impairment in drug-free patients with major depressive disorder. *The British Journal of Psychiatry*, *182*(3), 214–220. doi:10.1192/bjp.182.3.214

Posner, M. I., & DiGirolamo, G. J. (1998). Executive attention: Conflict, target detection, and cognitive control. In Parasuraman, R. (Ed.), *The attentive brain* (pp. 401–423). Cambridge, MA, US: The MIT Press.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*, 25–42. doi:10.1146/annurev.ne.13.030190.000325

Posner, M. I., Rothbart, M. K., Vizueta, N., Levy, K. N., Evans, D. E., Thomas, K. M., & Clarkin, J. F. (2002). Attentional mechanisms of borderline personality disorder. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(25), 16366–16370. doi:10.1073/pnas.252644699

Preiss, M., Kucerova, H., Lukavsky, J., Stepankova, H., Sos, P., & Kawaciukova, R. (2009). Cognitive deficits in the euthymic phase of unipolar depression. *Psychiatry Research*, *169*(3), 235–239. doi:10.1016/j.psychres.2008.06.042

Rabbitt, P. (Ed.). (1997). *Methodology of Frontal and Executive Function*. Hove, GBR: Psychology Press.

Reischies, F. M., & Neu, P. (2000). Comorbidity of mild cognitive disorder and depression—A neuropsychological analysis. *European Archives of Psychiatry and Clinical Neuroscience*, *250*(4), 186–193. doi:10.1007/s004060070023

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. doi:10.1016/j.bandc.2004.09.016

Riddle, T., & Suhr, J. (2012). Extension of the contingency naming test to adult assessment:
Psychometric analysis in a college student sample. *The Clinical Neuropsychologist*,
26(4), 609–625. doi:10.1080/13854046.2012.666265

Rose, S. A., Feldman, J. F., & Jankowski, J. J. (2011). Modeling a cascade of effects: The role
of speed and executive functioning in preterm/full-term differences in academic
achievement. *Developmental Science*, *14*(5), 1161–1175. doi:10.1111/j.1467-
7687.2011.01068.x

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful
control: Linking temperament, brain networks, and genes. *Child Development
Perspectives*, *1*(1), 2–7. doi:10.1111/j.1750-8606.2007.00002.x

Roth, R. M., Isquith, P. K., & Gioia, G. A. (2005). *BRIEF – A Behaviour Rating Inventory of
Executive Function – Adult Version: Professional Manual.* Lutz, FL: Psychological
Assessment Resources.

Salthouse, T. A., & Meinz, E. J. (1995). Aging, inhibition, working memory, and speed. *The
Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *50*(6),
297–306. doi:10.1093/geronb/50B.6.P297

Samyn, V., Roeyers, H., Bijttebier, P., Rosseel, Y., & Wiersema, J. R. (2015). Assessing
effortful control in typical and atypical development: Are questionnaires and
neuropsychological measures interchangeable? A latent-variable analysis. *Research in
Developmental Disabilities*, *36*, 587–599. doi:10.1016/j.ridd.2014.10.018

Sarapas, C., Shankman, S. A., Harrow, M., & Faull, R. N. (2013). Attention/processing speed
prospectively predicts social impairment 18 years later in mood disorders. *The Journal
of Nervous and Mental Disease*, *201*(9), 824–827.
doi:10.1097/NMD.0b013e31829db5ed

Sarapas, C., Shankman, S. A., Harrow, M., & Goldberg, J. F. (2012). Parsing trait and state

effects of depression severity on neurocognition: Evidence from a 26-year longitudinal

study. *Journal of Abnormal Psychology*, *121*(4), 830–837. doi:10.1037/a0028141

Scher, C. D., Ingram, R. E., & Segal, Z. V. (2005). Cognitive reactivity and vulnerability:

Empirical evaluation of construct activation and cognitive diatheses in unipolar

depression. *Clinical Psychology Review*, *25*(4), 487–510. doi:10.1016/j.cpr.2005.01.005

Scheurich, A., Fellgiebel, A., Schermuly, I., Bauer, S., Wölfges, R., & Müller, M. J. (2008).

Experimental evidence for a motivational origin of cognitive impairment in major

depression. *Psychological Medicine*, *38*(2), 237–246. doi:10.1017/S0033291707002206

Schiehser, D. M., Delis, D. C., Filoteo, J. V., Delano-Wood, L., Han, S. D., Jak, A. J., …

Bondi, M. W. (2011). Are self-reported symptoms of executive dysfunction associated

with objective executive function performance following mild to moderate traumatic

brain injury? *Journal of Clinical and Experimental Neuropsychology*, *33*(6), 704–714.

doi:10.1080/13803395.2011.553587

Schlosser, N., Wolf, O. T., & Wingenfeld, K. (2011). Cognitive correlates of hypothalamic–

pituitary–adrenal axis in major depression. *Expert Review of Endocrinology &

Metabolism*, *6*(1), 109–126. doi:10.1586/eem.10.79

Schmid, M., & Hammar, Å. (2013a). Cognitive function in first episode major depressive

disorder: Poor inhibition and semantic fluency performance. *Cognitive

Neuropsychiatry*, *18*(6), 515–530. doi:10.1080/13546805.2012.754748

Schmid, M., & Hammar, Å. (2013b). A follow-up study of first episode major depressive

disorder. Impairment in inhibition and semantic fluency—Potential predictors for

relapse? *Frontiers in Psychology*, *4*. 633. doi:10.3389/fpsyg.2013.00633

Schonfeld, A. M., Paley, B., Frankel, F., & O'Connor, M. J. (2006). Executive functioning

    predicts social skills following prenatal alcohol exposure. *Child Neuropsychology: A*

    Journal on Normal and Abnormal Development in Childhood and Adolescence, *12*(6),

    439–452. doi:10.1080/09297040600611338

Segrin, C. (2000). Social skills deficits associated with depression. *Clinical Psychology Review*,

    20(3), 379–403. doi:10.1016/S0272-7358(98)00104-4

Shallice, T., & Norman, D. A. (1986). Attention to action. In R. J. Davidson, G. E. Schwartz, &

    D. Shapiro (Eds.), *Consciousness and self-regulation: advances in research and theory*

    (Vol. 4, pp. 1–18). New York, NY: Plenum.

Shallice, T. (1988). *From Neuropsychology to Mental Structure*. Cambridge: Cambridge

    University Press. Retrieved from

    http://ebooks.cambridge.org/ref/id/CBO9780511526817

Shallice, T., & Burgess, P. (1993). Supervisory control of action and thought selection. In A. D.

    Baddeley & L. Weiskrantz (Eds.), *Attention: Selection, awareness, and control: A*

    tribute to Donald Broadbent (pp. 171–187). New York, NY: Clarendon Press/Oxford

    University Press.

Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe

    damage in man. *Brain: A Journal of Neurology*, *114*(2), 727–741.

    doi:10.1093/brain/114.2.727

Fennig, S., Mottes, A. (2002). Everyday memory and laboratory memory tests: General

    function predictors in schizophrenia and remitted depression. *The Journal of Nervous*

    and Mental Disease, *190*(10), 677–682. doi:10.1097/01.NMD.0000034931.67882.1B

Shuster, J., & Toplak, M. E. (2009). Executive and motivational inhibition: Associations with self-report measures related to inhibition. *Consciousness and Cognition*, *18*(2), 471–480. doi:10.1016/j.concog.2009.01.004

Smith, D. J., Muir, W. J., & Blackwood, D. H. (2006). Neurocognitive impairment in euthymic young adults with bipolar spectrum disorder and recurrent major depressive disorder. *Bipolar Disorders*, *8*(1), 40–46. doi:10.1111/j.1399-5618.2006.00275.x

Snyder, H. R. (2013). Major depressive disorder is associated with broad impairments on neuropsychological measures of executive function: A meta-analysis and review. *Psychological Bulletin*, *139*(1), 81–132. doi:10.1037/a0028727

Sobocki, P., Jönsson, B., Angst, J., & Rehnberg, C. (2006). Cost of depression in Europe. *The Journal of Mental Health Policy and Economics*, *9*(2), 87–98. Retrieved from http://www.icmpe.org/

Stanovich, K. (2011). *Rationality and the Reflective Mind*. New York, NY: Oxford University Press.

Stordal, K. I., Lundervold, A. J., Egeland, J., Mykletun, A., Asbjørnsen, A., Landrø, N. I., Lund, A. (2004). Impairment across executive functions in recurrent major depression. *Nordic Journal of Psychiatry*, *58*(1), 41–47. doi:10.1080/08039480310000789

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research*, *63*(3-4), 289–298. doi:10.1007/s004269900007

Swanson, J. (2005). The Delis-Kaplan Executive Function System: A review. *Canadian Journal of School Psychology*, *20*(1-2), 117–128. doi:10.1177/0829573506295469

Sweeney, J. A., Kmiec, J. A., & Kupfer, D. J. (2000). Neuropsychologic impairments in bipolar

and unipolar mood disorders on the CANTAB neurocognitive battery. *Biological

Psychiatry*, *48*(7), 674–684. doi:10.1016/S0006-3223(00)00910-0

Thompson, J. M., Gallagher, P., Hughes, J. H., Watson, S., Gray, J. M., Ferrier, I. N., & Young,

A. H. (2005). Neurocognitive impairment in euthymic patients with bipolar affective

disorder. *The British Journal of Psychiatry*, *186*(1), 32–40. doi:10.1192/bjp.186.1.32

Toll, S. W. M., Van der Ven, S. H. G., Kroesbergen, E. H., & Van Luit, J. E. H. (2011).

Executive functions as predictors of math learning disabilities. *Journal of Learning

Disabilities*, *44*(6), 521–532. doi:10.1177/0022219410387302

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-

based measures and ratings of executive function assess the same construct? *Journal of

Child Psychology and Psychiatry, and Allied Disciplines*, *54*(2), 131–143.

doi:10.1111/jcpp.12001

Van der Plas, E. A. A., Crone, E. A., van den Wildenberg, W. P. M., Tranel, D., & Bechara, A.

(2009). Executive control deficits in substance-dependent individuals: A comparison of

alcohol, cocaine, and methamphetamine, and of men and women. *Journal of Clinical

and Experimental Neuropsychology*, *31*(6), 706–719. doi:10.1080/13803390802484797

Verstraeten, K., Vasey, M. W., Raes, F., & Bijttebier, P. (2009). Temperament and risk for

depressive symptoms in adolescence: Mediation by rumination and moderation by

effortful control. *Journal of Abnormal Child Psychology*, *37*(3), 349–361.

doi:10.1007/s10802-008-9293-x

Waskom, M. L., Kumaran, D., Gordon, A. M., Rissman, J., & Wagner, A. D. (2014).

Frontoparietal representations of task context support the flexible control of goal-

directed cognition. *The Journal of Neuroscience*, *34*(32), 10743–10755.

doi:10.1523/JNEUROSCI.5282-13.2014

Weinberger, D. R., & Gallhofer, B. (1997). Cognitive function in schizophrenia. *International*

Clinical Psychopharmacology, *12*(Suppl. 4), 29–36.

Wilson, B. A. (1993). Ecological validity of neuropsychological assessment: Do

neuropsychological indexes predict performance in everyday activities? *Applied and*

Preventive Psychology, *2*(4), 209–215. doi:10.1016/S0962-1849(05)80091-5

Zhou, Q., Chen, S. H., & Main, A. (2012). Commonalities and differences in the research on

children's effortful control and executive function: A call for an integrated model of

self-regulation. *Child Development Perspectives*, *6*(2), 112–121. doi:10.1111/j.1750-

8606.2011.00176.x