ACCOUNTING FOR THE DELETERIOUS EFFECTS OF NATURALLY OCCURING AFFECT SUPPRESSION IN THE ASSESSMENT OF EXECUTIVE FUNCTIONING: A PROOF OF CONCEPT STUDY

by

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STATEMENT OF THESIS APPROVAL

The following faculty members served as the supervisory committee chair and members for the thesis of **Emilie Irene Franchow**.

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ABSTRACT

Affect suppression (AS) is an emotion regulation strategy that is known to be associated with temporary depletion of executive functioning. The purpose of this study was to examine the ramification of this effect on clinical neuropsychological evaluations, as well as whether this effect generalizes to working memory and processing speed. Fifty-six adults (mean age 22.89) completed the Burden of State Emotion Regulation Questionnaire (measuring AS burden generally vs. on the day of testing), subtests from the Delis-Kaplan Executive Function System, and the Wechsler Adult Intelligence Scale III Working Memory and Processing Speed subtests. Individuals with high AS burden on the day of testing exhibited poorer executive performance, but only when their general AS burden was low. The magnitude of this effect was clinically significant (i.e., 2/3 of *SD*). This effect held even after accounting of demographics, depression levels, processing speed, and working memory. AS did not account for variance in working memory or processing speed performances above and beyond executive functioning. These results suggest that AS burden on the day of testing has deleterious effects on executive functioning and represents a clinically meaningful bias in clinical evaluation.

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INTRODUCTION

In clinical neuropsychology, an important area of research is the continuing removal of systematic test-performance variance unrelated to neuropathology (Suchy, 2011). Although the field has become quite advanced in terms of accounting for demographically related variance (e.g., Advanced Clinical Solutions for the WAIS-IV and WMS-IV (Pearson Clinical Assessments, 2009)), a variety of situational factors also have systematic and measurable effects on cognitive test performance. For example, recent caffeine and carbohydrate intake (Maridakis, Herring, & O'Connor, 2009; Maridakis, O'Connor, & Tomporowski, 2009), sleep quality (Harrison & Horne, 2000), and time of day (Allen, Grabbe, McCarthy, Bush, & Wallace, 2008; Bennett, Petros, Johnson, & Ferraro, 2008) may all affect basic attention and executive functions in non-patient samples. Additionally, some situational factors can impact emotional states, which can also systematically affect performance. Some evidence suggests that induced dysphoric and euphoric moods correspond with better performance on right- and left-hemisphere dominant tasks, respectively (Bartolic, Basso, Schefft, Glauser, & Titanic-Schefft, 1999); that participants are more distracted by mood-congruent than by mood-incongruent stimuli (Gilboa-Schechtman, Revelle, & Gotlib, 2000); and that induced positive mood may be associated with temporarily poorer working memory (Martin & Kerns, 2011) and executive functioning (Oaksford, Morris, Grainger, & Williams, 1996).

Together, these findings support the value of taking situational factors into account when interpreting performance on standardized neuropsychological tests. However, there are currently no standard procedures for taking situational factors into account, in part due to scarcity of research on their specific impact on clinical evaluations, and in part due to the lack of assessment procedures that would adequately quantify them.

One situational factor that appears to affect cognition and has received increasing attention from researchers is engagement in affect suppression (AS). AS is an emotion regulation strategy characterized by effortful control of facial affect and other automatic emotional responses, such as laughter or crying (Gross, 1998). The need to transiently engage in AS is ubiquitous in human society, and context-appropriate use of AS is associated with positive interpersonal functioning (Gross, 2007). However, *chronic* or *prolonged* AS has been shown to have deleterious consequences. Physiologically, AS is an *in*effective strategy for eliminating emotional arousal, and may even increase, rather than dampen, amygdalar and autonomic activation associated with emotional experiences (Ohira et al., 2006). Thus, preferential use of AS over other emotion regulation strategies (e.g., cognitive reappraisal) is associated with negative emotional and physical health outcomes (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Denollet, Martens, Nyklíček, Conraads, & de Gelder, 2008; Moore, Zoellner, & Mollenholt, 2008; Myers et al., 2008). A growing body of research suggests that engagement in AS also has deleterious effects on executive functioning.

The deleterious effect of AS on cognition has been studied primarily within the realm of social psychology, where it is generally referred to as the "depletion of self-control" abilities (Baumeister, 2002). Specifically, the social literature associates AS with measurable decrements in subsequent executive functioning, and vice versa. Compared to controls, individuals who engage in acts of self-regulation tend to subsequently exhibit more behavioral dyscontrol, including poorer physical stamina (i.e., handgrip strength) and higher rates of impulsive spending, breaking diets, aggressive responses, and willingness to engage in inappropriate sexual behaviors (Baumeister & Alquist, 2009; Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven, Tice, & Baumeister, 1998). Participants depleted by self-regulatory acts are also more likely to be persuaded by weak arguments (Baumeister & Alquist, 2009), use simpler, more error-prone heuristics, and postpone decision-making (Pocheptsova, Amir, Dhar, & Baumeister, 2009). Cognitively, participants directed to regulate their response to an emotional stimulus *or* to engage in a cognitively-demanding executive task show poorer performance relative to controls on subsequent measures of logic and reasoning, cognitive extrapolation, response inhibition, and working memory (Inzlicht & Gutsell, 2007; Schmeichel, 2007; Schmeichel, Vohs, & Baumeister, 2003). Furthermore, targets of stereotype threat who *spontaneously* regulate the appearance of anxiety in response to threat priming perform more poorly on subsequent cognitive tests than do their non-suppressing peers (Johns, Inzlicht, & Schmader, 2008), suggesting that naturally-occurring AS may also be associated with cognitive underperformance in the near-term. Importantly, depletion is not instantly resolved with the removal of a taxing demand, but temporarily eliminates resources needed to respond optimally to subsequent demands for an indeterminate period (Baumeister, 2002b; Gailliot, 2010; Pocheptsova et al., 2009; Schmeichel et al., 2003; Stucke & Baumeister, 2006).

The mutually depleting effect between executive functioning and engagement in

AS can likely be explained by conceptualizing AS itself as an executive ability. By definition, AS requires both cognitive and behavioral control (abilities falling under the umbrella of executive functioning). Similar to executive functioning, AS is highly effortful (Gailliot, 2010); it involves controlling emotional reactions while *already* physiologically aroused (Gross & Levenson, 1993). In addition to the conceptual overlap between AS and executive functioning, neuroimaging evidence supports common neuroanatomic networks underlying both processes (i.e., dorsolateral, orbitofrontal, ventromedial, and anterior cingulate cortices) (Bechara, Damasio, & Damasio, 2000; Beer & Lombardo, 2007; Goldin, McRae, Ramel, & Gross, 2008; Ochsner & Gross, 2007; Spinella, 2007; Suchy, 2011).

Although the depleting relationship between AS and executive functioning has been consistently replicated in the social literature, it is unclear whether this effect represents a clinically relevant confound for neuropsychology, or whether it is too fleeting and negligible to have a meaningful impact on test performance. In other words, while the existing research base provides solid support for the depletion effect experimentally, translation of that effect into clinical neuropsychological practice requires a different approach. For instance, much of the existing research on the depletion effect shows that AS deleteriously affects performance on tasks *related to,* but not necessarily synonymous with, executive functioning. Some studies measure the effect of AS on behaviors in which executive abilities are implicated (i.e., suppressing aggressive responses to insults, resisting tempting foods, and persistence on difficult puzzles) without providing evidence of an underlying *cognitive* depletion (Baumeister, 2002a; Baumeister & Alquist, 2009; Baumeister, Gailliot, DeWall, & Oaten, 2006; Gailliot, 2010). Others have measured the effect of AS on working memory (e.g., the Operation Span task, reverse digit span) (Schmeichel, 2007) or deductive and inductive reasoning tasks (e.g., logic problems from standardized testing such as the GRE and the CET, Raven's Progressive Matrices, etc.) (Schmeichel et al., 2003; Shamosh & Gray, 2007). The few published studies measuring the effect of AS on a commonly accepted clinical measure of executive functioning have relied on a single measure as their outcome variable, such as the Stroop test (Inzlicht & Gutsell, 2007; Johns et al., 2008; Richeson, Trawalter, & Shelton, 2005). However, due to the hierarchical structure of cognition (Stuss, Picton, & Alexander, 2001), any single measure of executive functioning necessarily relies on a number of component processes (e.g., the Stroop test has visual-perceptual and processing speed components). Thus, when using a single measure, it is unclear whether an observed performance decrement is due to an effect on executive functions or an effect on one or more component processes.

The second reason for not understanding the clinical significance of the depletion effect is that the effect has not been directly demonstrated with naturally occuring AS. The majority of the existing research has experimentally manipulated AS by prohibiting participants from expressing their emotions while viewing disturbing images, being exposed to experimenter provocation, or being exposed to tempting stimuli (Baumeister et al., 1998; Inzlicht & Gutsell, 2007; Johns et al., 2008; Richeson et al., 2005; Schmeichel, 2007; Schmeichel et al., 2003; Shamosh & Gray, 2007; Stucke & Baumeister, 2006). While this methodology provides a well-controlled manipulation of AS, it does not tap into real-world AS as experienced in daily life, and therefore does not address whether everyday AS influences the results of clinical evaluations.

Purpose of the Current Study

The purpose of the current study was to demonstrate that certain situational factors (such as the depleting effect of AS) can be quantified, and that their impact on neuropsychological test performance can be accounted for (Suchy, 2011). To that end, we examined whether the depletion effect between AS and executive functioning demonstrated in the social literature is clinically relevant in neuropsychological evaluations. We had two specific aims: (1) to reproduce the depletion effect using standardized clinical measures of executive functioning and naturally-occurring AS assessed via self-report, and (2) to determine whether the effect is *specific to* executive functioning or whether it applies to related cognitive abilities confounded with executive functioning in previous studies (i.e., working memory and processing speed). To those ends, we administered a self-report measure of state AS along with a battery of cognitive tests, including measures of executive functioning, working memory, and processing speed, to a sample of young adults. We hypothesized that higher self-reported burden of state AS would account for variance in executive performance above and beyond known-contributors to higher cognitive abilities.

METHOD

Participants

Participants were 56 undergraduate volunteers enrolled in psychology courses at the University of Utah, who participated in exchange for credit. Depression was an exclusion criterion, since chronic low mood has known negative effects on executive performance (McDermott & Ebmeier, 2009) and would likely also be related to level of AS, thus presenting a confound in the relationship between our variables of interest. Participants were mostly female (64.3%), White/Caucasian (66.1%), and right-handed (87.5%). Their mean age was 22.89 years (18-37 years, *sd* = 4.986), and they were in their junior year of college on average (mean 14 years of education completed, 11-17 years, *sd* = 1.379).

Procedures

After undergoing informed consent procedures, participants completed a 3-hour long neuropsychological testing battery one-on-one with an examiner in the Neuropsychology Laboratory in the Social and Behavioral Sciences building on the University of Utah campus. The battery included measures designed to assess (a) the burden of AS, (b) executive functioning, (c) working memory, (d) processing speed, and (e) an estimate of crystallized intelligence as a measure of discriminant validity (since crystallized intelligence is considered to be separable from executive functioning abilities and therefore should be unrelated to AS). We used raw scores for all analyses. All procedures were in compliance with institutional and international standards for research with human participants (in compliance with the University of Utah IRB and the Helsinki Declaration).

Burden of affect suppression. The Burden of State Emotion Regulation Questionnaire (B-SERQ) was developed by the researchers as a measure of the burden of AS. The measure includes 15 questions regarding level of effort involved in acts of suppression that are asked twice, as they apply (1) over the past 2 weeks (baseline score)[1] and (2) over the past 24 hours (state score). Seven items ask about suppression of negative affect, four ask about suppression of positive affect, and four ask about valence-neutral AS (interpretable as suppression of either positive or negative affect). Items are scored on a 4-point scale, from "never" to "all the time." The subscales used in principle analyses include items found to contribute to internal consistency in this sample (see Results).

Executive functioning. The Delis-Kaplan Executive Function System battery (D-KEFS) (Delis, Kramer, Kaplan, & Holdnack, 2004) is a well-validated, widely used battery of executive measures. As we have done in prior research (Kraybill & Suchy, 2011; Kraybill, Thorgusen, & Suchy, 2012; Williams, Suchy, & Kraybill, 2010), we combined a subset of the D-KEFS subtests into a single composite of executive

[1] Because there are no accepted standards for determining high, average, and low burden of self-reported state AS, we included a baseline score in order to compare this with the burden on the day of testing. We were then able to determine whether absolute level of state burden, absolute level of baseline burden, the difference between the two (essentially using the baseline score as the normative standard), or all three measures would account for significant variance in executive functioning.

functioning. Creating a composite of several measures allows the variance accounted for by some of the component processes to cancel out (as different tasks require somewhat different component processes), while the variance that is shared by all three tasks (i.e., executive functioning) remains. The following tasks were used: Trail Making Test (Letter Number Sequencing Condition), Design Fluency, and Color-Word Interference (Inhibition Condition). Using factor analysis, the raw scores of these three subtests were combined into an executive functioning composite score (Cronbach's alpha = .535).

Working memory. The Wechsler Adult Intelligence Scale III (WAIS-III) Working Memory Index (WMI) is a widely accepted, highly reliable measure of the ability to hold in mind and manipulate information for a short period of time (Wechsler, 1997a). The following subtests were included in the composite: Digit Span, Arithmetic, and Letter Number Sequencing. Using factor analysis, the raw scores from these three subtests were combined into a single composite score (Cronbach's alpha = .790).

Processing speed. The WAIS-III Processing Speed Index (PSI) is a widely accepted measure of motor, perceptual, and mental speed that features excellent reliability (Wechsler, 1997a). Coding and Symbol Search subtests were included in the composite. Using factor analysis, the raw scores from these subtests were combined into a single composite score (Cronbach's alpha = .727).

Discriminant validity. Participants also completed the Wechsler Test of Adult Reading (WTAR) (PsychCorp, 2001), a widely used, highly reliable estimate of verbal IQ. This knowledge-based, nonexecutive measure of verbal intelligence allowed for examination of discriminant validity; performance on this task was expected to show no relationship with AS as measured by the B-SERQ.

Depression. The Beck Depression Inventory (BDI-II), a highly reliable screening measure for depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), was administered to further characterize the sample and to ensure no participants scored in the clinical range.

RESULTS

Preliminary Analyses

B-SERQ item selection. We computed Cronbach's alpha, examining B-SERQ state and baseline items separately (15 items each), and eliminated non-contributing/detracting items in a stepwise fashion until a set of only contributing items was identified. A set of 13 baseline items met this criterion and displayed excellent internal reliability (Cronbach's alpha = .811). These items tap inhibition of negative affect (*n*= 7), positive affect (*n*= 2), and generalized AS (*n*= 4) (see Table 1). For state AS, 11 items all contributed to good internal reliability (Cronbach's alpha = .795), including regulation of negative (*n*= 4), positive (*n*= 2), and generalized AS (*n*= 5) (see Table 2). Total scores for state and baseline AS were moderately correlated (r= .532, p<.01)[2].

Zero order correlations. Zero order correlations between state and baseline AS and cognitive variables (executive functioning, working memory, processing speed, and crystalized intelligence) showed a significant moderate relationship between executive functioning and working memory, processing speed, crystalized intelligence, and state AS. Working memory, processing speed, and crystalized intelligence were *not* related to either state or baseline AS (see Table 3).

[2] Additional findings on psychometric properties and construct validation of the B-SERQ will be reported elsewhere.

Principle Analyses

Aim 1: AS variance in executive functioning. To examine whether self-reported AS accounted for variance in executive functioning performance, we conducted a hierarchical regression with the executive composite score as the criterion and with age, years of education, and sex as predictors on Step 1 to control for demographic factors related to cognitive performance. Baseline and state AS scores were entered on Steps 2 and 3, respectively, to allow for examination of the contribution of state AS above and beyond participants' typical (or baseline) AS burden. Lastly, the interaction term (i.e., between baseline and state AS) was entered on Step 4 to account for the possible interaction between baseline level and state AS on the day of testing. Results are presented in Table 4 (Model 1). As can be seen in the table, the interaction significantly predicted executive performance, contributing 15.4% of variance above and beyond previous steps.

Considering the significant correlations among cognitive composites (Table 3), and in order to examine whether AS would continue to predict executive functioning performance *after* accounting for component processes, we repeated the hierarchical regression with working memory and processing speed composites added as predictors. Results are presented in Table 4 (Model 2). As can be seen in the table, while working memory and processing speed added significant variance to the prediction of executive functioning (36% collectively) above and beyond demographics, the AS interaction continued to contribute significantly above and beyond all previous steps (accounting for 7.1% of variance).

In order to interpret the interaction between state and baseline AS, we conducted a series of simple slopes analyses. As recommended by Cohen, Cohen, West, and Aiken (2003), we repeated the hierarchical regression (Model 2) centering baseline and state AS in turn at the median, one standard deviation below the median, and one standard deviation above the median. We used medians rather than means because state AS was positively skewed [skewness = 1.25]. Summaries of coefficients for the simple effects of state and baseline AS in these regressions are presented in Table 5. As can be seen in the table, all levels of state AS predicted executive functioning when baseline AS was low, but state AS was *un*related to executive functioning when baseline AS was centered at the median or high. In other words, state AS had a measureable impact on executive performance only for individuals who reported their baseline AS burden to be low.

To illustrate this interaction, we divided the sample into four groups based on the results of the simple slopes analyses. For state AS, we used median split to divide the sample into high (n= 29) and low (n= 27) state-AS groups. For baseline AS, we used a cutting point just *below* the median (separating individuals who were *below* the median from those who were *at or above* the median, per simple slopes results), again creating high (n=34) and low (n=22) baseline-AS groups. The resulting four AS groups included 23 participants reporting high burden on both state and baseline AS, 16 reporting low burden on both state and at baseline, 11 reporting low burden on state but high burden at baseline, and 6 reporting high burden on state and low burden at baseline. We generated estimated marginal mean executive composite scores for each group (correcting for age, education, sex, working memory, and processing speed) and graphed the results (see Figure 1). As can be seen in the figure, the highest (i.e., best) scores were produced by participants reporting low burden on both state and baseline AS, while the poorest scores were observed for those reporting low AS burden at baseline but high burden of state AS. Participants who were high or average at baseline exhibited an intermediate range of scores on the executive composite, regardless of their state levels.

To illustrate the clinical significance of these findings, we generated mean executive scaled scores (averaging the three subtests included in the composite) and graphed the results (see Figure 2). As can be seen in the figure, participants reporting low burden for baseline AS but high burden for state AS scored on average over 2/3 of a standard deviation (i.e., 2 scale scores) below those whose AS burdens were low at both baseline and state.

Aim 2: Affect suppression predicting component cognitive processes. In order to determine whether the depleting effect of AS is specific to executive functioning or whether it also applies to working memory and processing speed, we repeated the hierarchical regressions above with working memory and processing speed composite scores as the criterion variables. Results for working memory and processing speed are summarized in Tables 6 and 7, respectively. As can be seen in Table 6, the AS interaction contributed significant variance to the prediction of working memory performance. However, when executive functioning was added to the model, AS variables no longer contributed unique variance (see Model 2), suggesting that it was the executive demands of the task that were responsible for the relationship between AS and working memory. With respect to processing speed, only the executive functioning composite contributed significant variance to the model (19.4% above and beyond previous steps), while all AS variables remained nonsignificant in both models (see Table 7).

Discriminant Validity

To examine whether AS significantly predicted crystalized intelligence (as a measure of discriminant validity with minimal executive demands), we ran a hierarchical regression predicting WTAR raw score with demographics (age, education, and sex), baseline AS, state AS, and the interaction between the two AS scores entered on separate steps. As expected, AS did not contribute significantly to the model (p>.05).

Supplementary Analyses

Subclinical depression and the depletion effect. In order to ensure that the depleting effect of state AS in participants with low baseline AS was not attributable to the effects of subclinical depression in our sample, we repeated the Aim 1 hierarchical regression with depression (i.e., BDI-II total score) added as a predictor on Step 2. While depression contributed nonsignificantly to the prediction of executive functioning (p= .078), both state AS (F_{change} (1, 48) = 4.409, p= .041; R^2_{change} = .078) and the interaction (F_{change} (1, 47) = 9.223, p= .004; R^2_{change} = .139) added significant variance to prediction of executive functioning above and beyond previous steps.

Table 1. *Baseline Affect Suppression: Final Items*

Item (Valence)	Corrected Item-Total Correlation
1. I have made sure not to show my positive emotions. (P)	.325
2. I have made sure not to show my negative emotions. (N)	.449
3. I have worked hard to smile back at others. (N)	.459
4. I have forced myself to respond positively. (N)	.548
5. It has been difficult to maintain a neutral/pleasant facial expression. (G)	.486
6. It has been difficult to maintain an even tone of voice. (G)	.418
7. I have fought to hold back tears. (N)	.372
8. I have worked hard not to say what I was really thinking. (G)	.313
9. I have remained silent in order to keep myself from an angry outburst, or from saying something I didn't mean. (N)	.686
10. I have worked hard to control, for example, impulses to throw or hit things. (N)	.277
11. I have had to work hard to control/moderate my breathing. (G)	.553
12. I have worked hard not to show I was scared. (N)	.632
15. It has been difficult not to blurt out something I was excited about (where it was inappropriate or interrupted someone else). (P)	.357

Note. P = suppression of positive affect; N = suppression of negative affect; G = generalized/valence-neutral suppression.

Table 2. *State Affect Suppression: Final Items*

Item (Valence)	Corrected Item-Total Correlation
1. I have made sure not to show my positive emotions. (P)	.503
2. I have made sure not to show my negative emotions. (N)	.549
4. I have forced myself to respond positively. (N)	.476
5. It has been difficult to maintain a neutral/pleasant facial expression. (G)	.544
6. It has been difficult to maintain an even tone of voice. (G)	.450
8. I have worked hard not to say what I was really thinking. (G)	.383
9. I have remained silent in order to keep myself from an angry outburst, or from saying something I didn't mean. (N)	.567
11. I have had to work hard to control/moderate my breathing. (G)	.408
12. I have worked hard not to show I was scared. (N)	.385
14. I have worked hard not to make an inappropriate joke or comment. (G)	.508
15. It has been difficult not to blurt out something I was excited about (where it was inappropriate or interrupted someone else). (P)	.369

Note. P = suppression of positive affect; N = suppression of negative affect; G = generalized/valence-neutral suppression.

Table 3. *Zero Order Correlations Among Affect Suppression and Cognitive Domains*

	Executive Functioning	Working Memory	Processing Speed	Crystallized Intelligence
State AS	- .293*	- .195	- .174	- .161
Baseline AS	- .230	- .199	- .197	- .048
Executive Functioning		.515**	.434**	.432**
Working Memory			.290*	.453**
Processing Speed				.140

Note. State AS = affect suppression over the past 24 hours; Baseline AS = affect suppression over the past 2 weeks; Executive Functioning = D-KEFS subtest composite score; Working Memory = WAIS working memory subtest composite score; Processing Speed = WAIS processing speed subtest composite score; ** p<.01 (two-tailed), *p<.05 (two-tailed).

Table 4. *Predicting Executive Functioning*

Step	Predictor	R^2	Adjusted R^2	R^2 Δ	*F* Δ	*df*	*p* value
Model 1							
1	Age, Sex, Education	.001	-.058	.001	.015	3, 51	.997
2	Baseline AS	.054	-.021	.054	2.830	1, 50	.099
3	State AS	.095	.003	.041	2.224	1, 49	.142
4	Interaction	.249	.156	.154	9.839	1, 48	.003**
Model 2							
2	Working Memory, Processing Speed	.361	.296	.360	13.822	2, 49	.000**
3	Baseline AS	.369	.290	.008	.607	1, 48	.440
4	State AS	.386	.295	.017	1.283	1, 47	.263
5	Interaction	.457	.362	.071	5.979	1, 46	.018*

Note. State AS = affect suppression over the past 24 hours; Baseline AS = affect suppression over the past 2 weeks; Interaction = State AS x Baseline AS; Working Memory = WAIS working memory subtest composite score; Processing Speed = WAIS processing speed subtest composite score; ** p<.01 (two-tailed), *p<.05 (two-tailed).

Table 5. *Simple Slopes Coefficients*

AS Centering	β	Std. Error	*t*	*p* value
Baseline Average	-.008	.017	-.479	.634
State Average	-.042	.022	-1.944	.058
Baseline High	.020	.018	1.070	.290
State High	-.008	.022	-.376	.709
Baseline Low	-.036	.022	-1.633	.109
State Low	-.077	.030	-2.588	.013*
Baseline Average	.020	.018	1.070	.290
State High	-.042	.022	-1.944	.058
Baseline Average	-.036	.022	-1.633	.109
State Low	-.042	.022	-1.944	.058
Baseline High	-.008	.017	-.479	.634
State Average	-.008	.022	-.376	.709
Baseline Low	-.008	.017	-.479	.634
State Average	-.077	.030	-2.588	.013*
Baseline Low	.020	.018	1.070	.290
State High	-.077	.030	-2.588	.013*
Baseline High	-.036	.022	-1.633	.109
State Low	-.008	.022	-.376	.709

Note. Baseline Average = Baseline AS centered at the median; Baseline Low = Baseline AS centered one standard deviation below the median; Baseline High = Baseline AS centered one standard deviation above the median; State Average = State AS centered at the median; State Low = State AS centered one standard deviation below the median; State High = State AS centered one standard deviation above the median; ** $p<.01$ (two-tailed), *$p<.05$ (two-tailed).

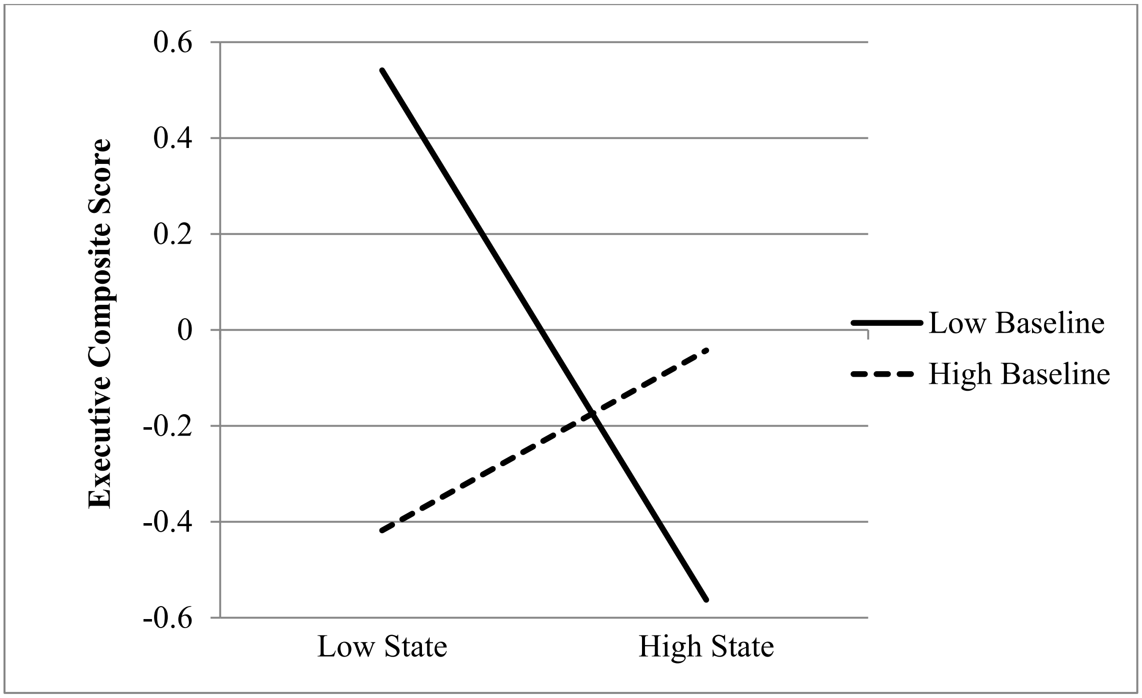

Figure 1. The figure illustrates the interaction between state (past 24 hours) and baseline (past 2 weeks) burden of affective suppression (AS). As can be seen from the figure, only individuals with low baseline burden of AS were deleteriously affected by high state burden of AS. In contrast, individuals with high baseline AS exhibit somewhat lower levels of executive functioning, regardless of their state AS burden.

Executive functioning composite scores is a factor score of three subtests from the D-KEFS subtests.). Low State = State AS scores below the median; High State = State AS scores above the median; Low Baseline = Baseline AS scores just below the median and lower; High Baseline = Baseline AS scores at the median and above. Higher composite scores represent better performance.

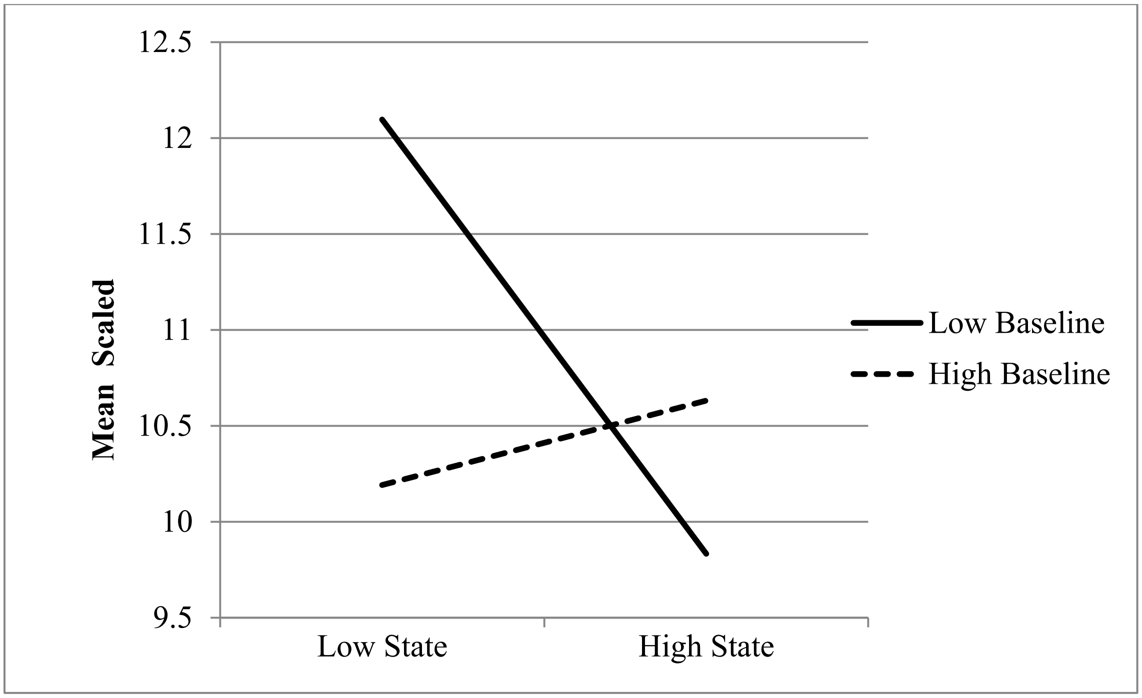

Figure 2. The figure illustrates the clinical significance of the interaction between state (past 24 hours) and baseline (past 2 weeks) burden of affective suppression (AS). Among individuals with low baseline AS, those who were high on the day of testing performed approximately 2/3 of a standard deviation below those who continued to be low on the day of testing. In contrast, individuals with high baseline AS exhibited a similar level of executive performance regardless of their state AS burden.

Mean executive functioning scaled scores (i.e., D-KEFS subtests) by baseline AS (affect suppression over the past 2 weeks) and state AS (affect suppression over the past 24 hours). Low State = State AS scores below the median; High State = State AS scores above the median; Low Baseline = Baseline AS scores just below the median and lower; High Baseline = Baseline AS scores at the median and above. Higher scaled scores represent better performance.

Table 6. *Predicting Working Memory*

Step	Predictor	R^2	Adjusted R^2	R^2 Δ	F Δ	*df*	*p* value
Model 1							
1	Age, Sex, Education	.026	-.031	.026	.457	3, 52	.713
2	Baseline AS	.063	-.010	.038	2.045	1, 51	.159
3	State AS	.074	-.018	.011	.587	1, 50	.447
4	Interaction	.193	.094	.119	7.204	1, 49	.010*
Model 2							
2	Executive Functioning	.287	.230	.261	18.283	1, 50	.000**
3	Baseline AS	.293	.221	.006	.411	1, 49	.524
4	State AS	.293	.204	.000	.002	1, 48	.969
6	Interaction	.321	.219	.028	1.93	1, 47	.171

Note. State AS = affect suppression over the past 24 hours; Baseline AS = affect suppression over the past 2 weeks; Interaction = State AS x Baseline AS; Executive Functioning = D-KEFS subtest composite score; ** p<.01 (two-tailed), *p<.05 (two-tailed).

Table 7. *Predicting Processing Speed*

Step	Predictor	R^2	Adjusted R^2	$R^2\,\Delta$	$F\,\Delta$	*df*	*p* value
Model 1							
1	Age, Sex, Education	.070	.016	.070	1.3	3, 52	.284
2	Baseline AS	.104	.034	.034	1.953	1, 51	.168
3	State AS	.115	.026	.011	.593	1, 50	.445
4	Interaction	.115	.007	.000	.024	1, 49	.879
Model 2							
2	Executive Functioning	.276	.218	.194	13.397	1, 50	.001**
3	Baseline AS	.284	.211	.008	.577	1, 49	.451
4	State AS	.285	.195	.000	.017	1, 48	.897
5	Interaction	.305	.201	.020	1.373	1, 47	.247

Note. State AS = affect suppression over the past 24 hours; Baseline AS = affect suppression over the past 2 weeks; Interaction = State AS x Baseline AS; Executive Functioning = D-KEFS subtest composite score; ** $p<.01$ (two-tailed), *$p<.05$ (two-tailed).

DISCUSSION

The current project was a proof of concept study designed to investigate (1) whether the depleting effect of AS on executive functioning, observed in experimental settings, can be quantified and related to neuropsychological test performance, and, if so, (2) whether the depleting effect of AS is specific to executive functioning (as opposed to working memory, processing speed, or crystallized intelligence). To those ends, we examined the relationship between self-reported burden of state AS and performances on standardized tests of executive functioning, working memory, processing speed, and crystalized intelligence commonly used in clinical neuropsychological evaluations.

The first key finding is that individuals with normally low burden of AS exhibit considerable executive decrements when their AS burden is high within 24 hours of testing. In contrast, individuals reporting average or high baseline AS exhibited executive performances that were apparently unaffected by the burden of state AS. This relationship held after accounting not only for demographics, but also for subclinical depression, working memory, and processing speed. The second key finding is that this depletion effect appears to be specific to executive functioning, and does not apply to performance on measures of working memory, processing speed, or crystallized intelligence. To our knowledge, this is the first study to use self-reported burden of AS, and first to demonstrate the clinical significance of the depletion phenomenon.

These results contribute to evolving conceptualizations of executive functioning, showing that AS is a distinctly executive ability, or, conversely, that executive functioning is comprised not only of cognitive processes, but also at least some aspects of emotion regulation. These results are consistent with previously reported functional and neuroanatomic overlap between AS and executive functioning (Bechara et al., 2000; Beer & Lombardo, 2007; Goldin et al., 2008; Ochsner & Gross, 2007; Spinella, 2007; Suchy, 2011). The current study takes these associations a step further by accounting for the contributions of component cognitive processes to executive functioning, demonstrating a relative lack of association between AS and these component processes. This suggests that the depletion effect is indeed related to recruitment of higher order executive functioning, as opposed to monopolization of basic attentional resources (Gross, 2007).

These results also demonstrate the relevance of the depletion effect for clinical neuropsychological evaluations. First, we show that situational factors (such as recently high burden of AS) account for significant variance in executive functioning performance, thereby potentially biasing assessment results for some patients. Importantly, among participants who reported their AS burden to be typically low, AS-related decrements in performance were 2/3 of a scale score standard deviation on average. A performance change of this magnitude is enough to classify participants into different performance categories; specifically, while participants with low baseline and state AS burden performed in the high average range, participants with high baseline AS burden showed average performance. Such potential bias highlights the need for the refinement of methods that would allow us to correct test scores for recent AS burden.

Furthermore, we measured the depletion effect in a nonpatient sample of individuals without obvious executive deficits (the sample's mean D-KEFS scale scores were fully within the average range, 8-14). It is possible that individuals with executive deficits are even *more* susceptible to depletion than are healthy young individuals. In fact, it is not uncommon for patients and their families to report considerable variability in executive abilities on a daily basis, reporting lapses that are not necessarily reflected in test results. Thus, understanding the relationship between AS burden and executive functioning in various patient groups may allow for a more accurate representation of cognitive skills under optimal conditions as well as offering a comparison between cognition on "good" and "bad" days.

These results also call into question the extent to which common clinical practices of creating a supportive, positive environment during testing eliminates the depletion effect. Our results suggest that AS burden anytime within the past 24 hours (i.e., not necessarily tied to a particular event during testing) is associated with demonstrably poorer executive performance. Therefore, the potentially deleterious effects of suppression on executive functioning are not entirely prevented by controlling the participant/patient's immediate testing environment.

In addition to clinical ramifications, these findings offer a new methodology that can be employed in research. In particular, the B-SERQ appears to offer a viable alternative to experimental manipulation of AS burden. This is particularly relevant for examination of the depletion effect among patients for whom affective dysregulation tends to coincide with deficits in executive functioning, including many dementing illnesses (Ritchie & Lovestone, 2002) and traumatic brain injury (Fann, Burnington, Leonetti, Jaffe, Katon, & Thompson, 2004). However, it may be impossible, impractical, or unethical to experimentally manipulate AS burden (which often involves inducing unpleasant emotional arousal) in vulnerable patient populations. In contrast, simply assessing naturalistically occurring AS burden via self-report makes it logistically possible to examine the depletion effect in a wide range of clinical populations with minimal upset to participants. While a number of scales measuring *trait* affect regulation/coping styles are available for use in research and clinical assessments (e.g., the Emotion Regulation Questionnaire (Gross & John, 2003), the Cognitive Emotion Regulation Questionnaire (Garnefski, Kraaij, & Spinhoven, 2001), the Inventory of Cognitive Affect Regulation Strategies (Kamholz, Hayes, Carver, Gulliver, & Perlman, 2006), and the Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004)), we are unaware of any currently published scales measuring the clinically relevant *burden* of *state* AS. Based on our results, the B-SERQ (developed by the researchers for this study) demonstrates promise as a new measure of state AS for use in future studies.

Limitations and Future Directions

The present study has several potential limitations. First, we examined the association between AS and executive functioning in a predominantly female (64.3%), White (66.1%), college-educated (14 years of education on average) adult sample. It is possible that differences in the observed effect exist based on ethnic, cultural, and even religious differences (due to differences in the meaning, effortfulness, acceptability, or frequency of AS) that were not examined in this study. Age differences might also exist, such that effort associated with AS differs for children and older adults. Therefore, the generalizability of these results in the general population may be limited. Future studies should examine this effect in larger, more ethnically and culturally diverse samples and across the lifespan.

Second, because different sets of items were included in state and baseline AS scores, it is possible that these scores captured slightly different constructs (see Tables 1 and 2). A greater number of items and greater range of scores contributed to slightly higher reliability of baseline AS (α= .811) than state AS (α= .795). Therefore, it is possible that baseline AS represents a slightly different construct (e.g., personality traits closely related to propensity for AS) than state AS, rather than the same construct over a different time period. However, our sample size is inadequate for the purpose of performing statistical analyses for construct validity of the B-SERQ.

Third, these results show that AS predicts executive functioning beyond variance accounted for by depressive symptoms in a *nondepressed* sample. However, it will be important to examine the extent to which AS burden impacts executive functioning in mood-disordered populations. Given that individuals with mood disorders likely have chronically-high AS burden, and severely-depressed individuals exhibit executive weaknesses (Wang et al., 2008; Rogers et al., 2004), it is possible that chronic burden of AS contributes to these cognitive limitations in this population.

Finally, all executive functioning tests in our battery are timed, demanding speeded performance. However, unlike previous studies, we included separate measures of processing speed to account for this component cognitive skill. Future studies may wish to include untimed executive functioning measures in order to more directly compare executive functioning *without* processing speed to executive functioning *with* processing speed. It is at least possible that AS affects performance where the total cognitive load is greatest (executive functioning plus processing speed plus working memory demands), and not necessarily performance on less demanding (i.e., untimed) planning and organization tasks. Speed demands and time limits also contribute to the modest reliability of the D-KEFS subtests. Therefore, these results should be replicated and examined longitudinally to determine the consistency of the relationship between state AS and performances across different studies, executive functioning measures, and retest intervals.

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