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Working memory deficits in personality disorder traits: A preliminary investigation in a nonclinical sample

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ABSTRACT

The purpose of the present study was to explore cognitive symptoms of personality disorder traits by means of Baddeley's working memory model. Forty-nine college students were tested for personality disorder traits with the Coolidge Axis II Inventory, and they were given measures assessing executive control, working memory, including general working memory capacity (Operation-Word Span), phonological storage capacity (digits forwards and digits backwards), and three other Wechsler Adult Intelligence Scale subtests. The results indicated that the 14 personality disorder scales had strong positive correlations with a measure of executive function deficits. Among measures of working memory capacity, the Digits Backwards subtest appeared to be the strongest predictor (negatively) of personality disorders according to multiple regressions. It was concluded that personality disorders may express themselves in cognitive ways that are reflected in measures of executive control, working memory capacity, and phonological storage capacity. Directions for further research are offered.

1. Introduction

Personality disorders are among the most debilitating but poorly understood category of mental illness (e.g., Segal, Coolidge, & Rosowsky, 2006). The *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV-TR*; American Psychiatric Association [APA], 2000) defines personality disorders as enduring and maladaptive behavior patterns of perceiving, relating to, and thinking about the environment and oneself that may manifest themselves in at least two of the following areas: cognition, affectivity, interpersonal functioning, or impulse control. The *DSM-IV-TR* provides the following definition for cognition: ways of perceiving and interpreting oneself, other people, and events. A review of the literature reveals a substantial base of research for this aspect of cognitive theory. For example, Beck et al. (2001) conceptualized the essence of a personality disorder as dysfunctional core beliefs that characterize and perpetuate the maladaptive patterns.

Other cognitive theorists (e.g., Rudman, 2004) have noted that the behavioral consistency shown within personality disorders may in fact stem from a more basic human motivation for consistency, and consistency itself often provides individuals with a more predictable environment (even if negative) and often reduces the anxiety that can be associated with change (Schmidt & Lerew, 2002). It has also been postulated that the extreme behavioral instability and impulsivity associated with borderline personality disorder could arise from rigidly held maladaptive core beliefs (e.g., Reeves & Taylor, 2007). Other cognitive theorists (in the tradition of A.T. Beck) have hypothesized that the need for cognitive consistency may help to explain why maladaptive beliefs are often overgeneralized in ineffective ways in interactions with others which produce the maladaptive behaviors seen in personality disorders (e.g., Young, Klosko, & Weishaar, 2003), with these patterns often remaining relatively stable across the adult lifespan (Segal et al., 2006).

The personality disorder literature regarding traditional neuropsychological aspects of cognition is vast. For example, much has been written about neuropsychological deficits in antisocial personality disordered individuals and individuals with psychopathic traits (e.g., Deckel, Hesselbrock, & Bauer, 1996; Dolan & Anderson, 2002; Eysenck, 1964; Lykken, 1957; Millon & Davis, 2004; Sellbom & Verona, 2007), incarcerated individuals with personality disorders (Bergvall, Nilsson, & Hansen, 2003), and borderline personality disordered patients (e.g., Lampe et al., 2007). Additionally, Besteiro-González, Lemos-Giráldez, and Muñiz (2004) found evidence for neuropsychological deficits for Cluster A personality disorders. The focus of the present paper, however, is upon cognitive deficits in personality disorders from the perspective of the working memory paradigm.

The working memory model, as originally conceived in 1974 by Baddeley and Hitch, has become one of the most provocative, predominant, and empirically substantiated memory models in the cognitive sciences in the past three decades (for a more complete review see Baddeley, 2000, 2001; Engle & Kane, 2004; Hazy,

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Frank, & O'Reilly, 2006; Miyake & Shah, 1999; Miyake et al., 2000; Shah & Miyake,1996, 2005). As currently conceived, working memory is a multi-component cognitive system reflecting a capacity to hold and manipulate information in active attention consistent with short- and long-term goals, in spite of task-irrelevant interference. The working memory model consists of a central executive, whose functions appear to be synonymous with the neuropsychological term *executive functions of the frontal lobes*, which have been documented by over five decades of empirical research (e.g., Goldberg, 2001; Lezak, 1995; Luria, 1966). These central executive functions include active attention to tasks at hand consistent with short- and long-term goals, inhibition of pre-potent but inappropriate responses, inhibition of irrelevant external stimuli, selection of appropriate actions, and updating and reorganization of relevant information held in attention (e.g., Oberauer, Süβ, Schulze, Wilhelm, & Wittman, 2000; Oberauer, Süβ, Wilhelm, & Wittman, 2003).

Baddeley (2001) also proposed that the central executive manipulates two subsystems, (a) phonological storage with vocal and subvocal articulatory processors (the phonological loop), and (b) a visuospatial sketchpad that temporarily records visual and spatial information. In 2000, Baddeley proposed an episodic buffer that integrates information from these two subsystems by means of a multimodal code and serves as a temporary store for this information and other material at the behest of the central executive. Baddeley proposed that it is episodic in the sense that it can hold integrated scenes, stories, or personal episodes in temporary consciousness. Baddeley also proposes that retrieval from the buffer is the nature of consciousness, and its binding functions are assumed to be the principal biological advantage of consciousness. Furthermore, because the episodic buffer allows multiple sources of information to be considered simultaneously, it may allow the creation of models of the environment that can be used to solve problems, offer and compare options, and to make plans for future behaviors.

Some recent research into the working memory model is concerned with its relationship to other higher cognitive activities such as language, reasoning, and intelligence. One common research strategy in these research studies has been to identify people who appear to have greater and lesser working memory capacity (also labeled *working memory span*). However, because there is no single definitive measure of working memory capacity, the results vary as a function of the domain-specificity of the task. For example, general working memory span has been found to be highly predictive of fluid intelligence, the kind of intelligence involved in novel-problem solving (e.g., Engle & Kane, 2004; Engle, Tuholski, Laughlin, & Conway, 1999).

1.1. Functions of the central executive and personality disorders

Lezak (1982) proposed that the executive functions of the frontal lobes were "... the heart of all socially useful, personally enhancing, constructive, and creative abilities ..." (p. 281). Furthermore, she thought that the impairment or loss of executive functions severely compromised a person's ability to be independent, constructively self-serving, and socially productive, regardless of how well preserved the other cognitive abilities were. She noted that some of the psychological or behavioral changes that may result from frontal lobe damage might include lack of inhibition and poor self control, lack of self direction, emotional lability, flattened affect, irritability, impulsivity, carelessness, rigidity, and difficulty in shifting attention. It is interesting to note that Lezak's list of symptoms of dysfunction of the executive functions of the frontal lobes is synonymous with many of the symptoms of individuals with personality disorders.

Coolidge, Thede, and Jang (2004) noted that a review of the *DSM-IV-TR* criteria for the borderline, dependent, depressive, histrionic, passive–aggressive, and avoidant personality disorders reveals significant overlap with executive function deficits. For example, the criteria for these specific personality disorders include goal attainment problems, impulsivity, impulsiveness in the decision-making, uncertainty in essential and daily decisions such as the determination of self-image, trouble setting short- and long-term goals, difficulty initiating projects, functioning independently, unassertiveness, a tendency to follow rather than lead others, excessive suggestibility (i.e., opinions and feelings that are easily influenced by others), low frustration tolerance for delays in gratification, erratic behavior, and resistance to occupational advancement. Where as the criteria for avoidant personality disorder have explicit assumptions that the resistance to occupational advancement is due to feelings of inadequacy, doubts of social competency, and the aversion to social interactions, it is interesting to speculate whether the resistance is actually due to some maladaptive core belief, central executive decision-making difficulty, and/or the lack of inhibition of the pre-potent response to evaluate one's self negatively.

One the first studies to establish the role of central executive function deficits and personality disorders was conducted by Coolidge, DenBoer, and Segal (2004). In their study of children and adolescent twins, they found that central executive function deficits and personality disorders were individually highly heritable (central executive function deficits, .77; 11 personality disorders, median = .69). More importantly, the bivariate heritability between executive function deficits and the personality disorder scales, that is, their common additive genetic origin, ranged from .27 for the schizoid personality disorder to .64 for the histrionic personality disorder with a median of .52 for nine of the 12 personality disorder scales. Coolidge et al. concluded that their findings may provide some insight as to why individuals diagnosed with specific personality disorders frequently exhibit chronic difficulties with everyday decisions, selective attention and inhibition, judgments, choices, planning, and flexibility. Their findings may also explain why therapeutic interventions with personality disordered individuals are so difficult and prognoses associated with personality disorders are generally so poor (e.g., Segal et al., 2006).

Recently, there appears to be a growing interest in understanding personality disorders from the perspective of the working memory paradigm. For example, in study of patients with schizotypal personality disorder, there were demonstrated deficits in visual perception and some working memory tasks (Farmer et al. 2000; Roitman et al., 2000). In similar visual perception and working memory tasks, Stevens, Burkhardt, Hautzinger, Schwarz, and Unckel (2004) found deficits in patients diagnosed with borderline personality disorder. We could locate only one recent study that investigated personality disorders and phonological deficits. Most typically in neuropsychological and other studies, phonological storage has been measured by the Wechsler Adult Intelligence Scale's Digit Span subtest. The latter task requires people to repeat an increasing series of numbers forwards and then backwards. Harvey, Reichenberg, Romero, Granholm, and Siever (2006) found that patients diagnosed with the schizotypal personality disorder had significantly shorter digit spans than patients with other personality disorders or control participants without personality disorders. However, Harvey et al. did not differentiate between performance on digits forwards and digits backwards. This differentiation may be critically important to measures of executive control as digits forward may involve only the maintenance function of the central executive (the simple phonological loop), whereas digits backwards appears to require not only active maintenance of the information but also inhibition of pre-potent responses (being asked to recall information in the order it was presented), and updating and reorganization of the information held in active memory. As such, the digits forward task appears to tap strictly the articulatory processor of the phonological loop in Baddeley's model, whereas the Digits Backwards task appears to measure articulatory processing and some central executive functions associated with general working memory capacity (e.g., Ostrosky-Solis & Lozano, 2006).

1.2. Is there a depletion of executive control functions in working memory in personality disordered individuals?

In a provocative recent study with many implications for the development and perpetuation of personality disorders, Schmeichel (2007) found evidence for the hypothesis that initial efforts at executive control appear to deplete subsequent efforts at executive control or working memory capacity. In his first two experiments, Schmeichel found that attempts to control visual attention or to inhibit pre-potent motor tendencies appeared to reduce later tasks that tap working memory capacity. In a third experiment, Schmeichel found that performing a demanding working memory capacity task reduced the subsequent capacity to inhibit emotional responses to a stressful film clip. Importantly, Schmeichel found that poorer inhibitory emotional control only occurred in prior working memory tasks that required executive control updating but not in maintenance-only tasks. In a fourth experiment, exaggerating emotional responses (rather than inhibiting them) also deleteriously affected subsequent working memory tasks.

In the present study, it was reasoned that if some individuals with significant personality disorder features do have working memory deficits, given the well demonstrated role of maladaptive core beliefs in the maintenance of personality disorders, then inner speech (as represented by subvocal articulatory processing or Baddeley's conception of phonological storage) might be a critical factor. Phonological storage has previously been shown to be heavily involved in the learning and comprehension of language, vocabulary breadth, and fluid intelligence (e.g., Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service, & Martin, 1997). The phonological loop has also recently been shown to be crucial to the understanding and production of metaphors. Metaphor production allows people to make mental connections across distinct conceptual realms and has been shown to be useful in problem solving (e.g., Chiappe & Chiappe, 2007).

1.3. Present hypotheses

In light of the Schmeichel (2007) study and earlier studies and reviews indicating a possible predictive relationship between working memory, executive functions, and personality disorders, it was hypothesized that phonological storage capacity, as measured in particular by the backward digit span task, would be negatively correlated with personality disorder traits. It was predicted that the relationships would be stronger for those personality disorders where emotional disinhibition might be stronger (histrionic and borderline) or emotional control might be greater (schizoid) than personality disorders where affectivity is not a prominent symptom.

2. Method

2.1. Participants

Participants were 49 undergraduates at a midwestern university, who received extra credit in exchange for their participation. There were 15 males and 34 females, mean age = 20.4 years, age range = 18–40 years, 35 (71%) reported their ethnicity as White, eight (16%) were Hispanic, and six others (12%) reported their ethnicity as Black, Asian, or other. Their marital status was largely single (94%).

2.2. Materials

2.2.1. Intelligence

Three subtests from the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) were used: Vocabulary, Block Design, and Matrix Reasoning. These tests were used to assess verbal IQ or crystallized intelligence (g_c), performance IQ, and fluid intelligence (g_f; novel-problem solving), respectively. The Vocabulary subtest of the WAIS-III has the highest correlation with Full Scale IQ of any of the subtests ($r = .81$; Kaufman & Lichtenberger, 2002).

2.2.2. Phonological storage capacity

The Digit Span subtest from the WAIS-III consists of a combination of its two subtests: Digit Span Forwards and Digit Span Backwards, and the latter two were used in the present study. As noted previously, Digit Span Forwards appears to measure maintenance of information in active memory without exceptional need for executive control. Digit Span Backwards has been shown to be both a measure of phonological maintenance, the inhibition of pre-potent responses (suppression of the recall of information in the order it was presented), and shifting or reorganizing tasks while holding both task goals in active memory (e.g., Ostrosky-Solis & Lozano, 2006; Thomas, Milner, & Haberlandt, 2003).

2.2.3. Working memory

Two tests of overall working memory capacity were administered: the Letter–Number Sequencing subtest of the WAIS-III and a computerized version of the Operation-Word Span (OSPAN; Conway et al., 2005) task. The Letter–Number Sequencing subtest measures the participant's ability to maintain and manipulate information in memory. In this subtest, the participant is given an increasingly longer list of randomly ordered letters and numbers, and is asked to repeat the numbers, giving first the numbers in numeric order (i.e., lowest to highest), then the letters in alphabetical order. The participant receives one point for each correctly re-ordered set of letters and numbers.

The OSPAN is an individually-administered task which asks participants to maintain in working memory brief lists of words while attempting to solve simple math problems. Participants are shown fifteen series of "operation-word strings" consisting of a question about a mathematical operation followed by a single word. The OSPAN has been established as a reliable and valid measure of working memory capacity (e.g., Conway et al., 2005; Klein & Fiss, 1999).

2.2.4. Central executive functions

Central executive functions were assessed by 16-item Executive Functions Deficits scale from the Coolidge Axis II Inventory (CATI; Coolidge, 2006; Coolidge & Merwin, 1992), which has been empirically demonstrated to be a reliable and valid measure of executive function deficits of the frontal lobes (e.g., Coolidge & Griego, 1995). Factor analysis of the scale has revealed a three component structure: decision-making difficulties, poor planning, and task initiation and completion difficulties (Coolidge & Griego).

2.2.5. Personality disorder traits

The 250-item, self-report CATI was also used to measure 14 personality disorders (and traits). The 14 personality disorder scales of the CATI were created directly from the criteria from the 12 personality disorders in *DSM-IV-TR* and its appendix and 2 personality disorders from the appendix of *DSM-III-R* (APA, 1987). The CATI has been shown to have good reliability and validity in a variety of clinical and nonclinical settings (e.g., Coolidge, 2006; Coolidge & Merwin, 1992).

2.3. Procedure

In most cases, approximately one week prior to the scheduled testing, participants were given or mailed an informed consent form and a set of instructions for completing the CATI. They were asked to complete the CATI prior to the individual testing sessions. Upon arriving for testing, the tests were administered by an MA graduate student (or her undergraduate assistants). All were thoroughly trained by the senior author in the tests' administration. The tests were given in the following order: Vocabulary, Digit Span, Block Design, Letter–Number Sequencing, Matrix Reasoning, and OSPAN. After administering the tests, the participants were debriefed.

3. Results

3.1. Personality disorder traits in a nonclinical sample

Although numerous studies have previously demonstrated the general validity of studying personality disorder traits in nonclinical samples (e.g., Millon & Davis, 2004; Widiger & Mullins-Sweatt, 2007), the present personality disorder scales sums were examined to determine whether sufficient variability was present to test the present hypotheses. Examination of the frequency distributions of the 14 CATI personality disorder scales revealed that no scale mean was less than 1/2 of a *SD* below the normative CATI scale means (which would have been indicative of excessive denial). Furthermore, each of the 14 personality disorder scales had at least one participant greater than 1 *SD* from the normative mean, and eight of the 14 personality disorder scales had at least one participant at least 2 *SDs* above the normative mean. In summary, there was more than sufficient variation in this nonclinical sample to analyze these scales in a dimensional manner.

3.2. Intelligence as a confounding variable

To rule out the possibility that intelligence might have been a major confounding variable in the study, the WAIS-III Vocabulary scaled score was first correlated with the CATI Executive Functions Deficits scale (EFD), OSPAN (corrected sets total score), and the 14 CATI personality disorder scales. The Vocabulary subtest is well known to be a reliable and valid measure of general intelligence (full scale IQ or FIQ on the WAIS) and crystallized intelligence (e.g., Kaufman & Lichtenberger, 2002). As expected, the Vocabulary scaled score was only weakly correlated with OSPAN ($r = .17$, $p > .05$), and the EFD scale ($r = -.07$, $p > .05$). With regard to the personality disorder scales, none of the correlations with the Vocabulary score reached $r > .30$ or $r < -.30$.

The WAIS-III Block Design scaled score was also correlated with the CATI EFD scale, OSPAN, and the 14 CATI personality disorder scales. The Block Design test is a well established measure of nonverbal intelligence (performance IQ or PIQ on the WAIS) and visual–spatial perception problem solving. The Block Design scaled score was weakly correlated with OSPAN ($r = .25$, $p > .05$), and the EFD scale ($r = -.06$, $p > .05$). With regard to the personality disorder scales, only one of the correlations with the Block Design score reached $r > .30$ or $r < -.30$ and that was a negative correlation with avoidant personality disorder ($r = -.32$, $p < .05$). Finally, the WAIS-III Matrix Reasoning scaled scores were correlated with the CATI EFD scale, OSPAN, and the 14 CATI personality disorder scales. Matrix reasoning is thought to be a measure of nonverbal problem solving and fluid intelligence. The Matrix Reasoning scaled score was weakly correlated with OSPAN ($r = .26$, $p > .05$), and the EFD scale ($r = .05$, $p > .05$). With regard to the personality disorder scales, none of the correlations with the Matrix Reasoning score reached $r > .30$ or $r < -.15$.

3.3. Central executive functions and personality disorders

As the executive functions measure (CATI EFD scale) resided within the same measure of personality disorders (CATI) and as there is *DSM-IV-TR* criterion-item overlap between the 16-item EFD scale and seven of the 14 personality disorder scales of the CATI, the items that overlapped on the personality disorder scales were eliminated from the first analysis, which was a correlation between the EFD scale and each of the 14 personality disorders. The results of this analysis appear in Table 1. As can be seen, 12 of 14 personality disorders had significant correlations with the Executive Functions Deficits at $r > .34$ or greater, which supports hypothesis that central executive function deficits may indeed be associated with personality disorders. This finding supports the general contention in *DSM-IV-TR* that personality disorders may manifest themselves in cognitive fashion, and not just within traditional cognitive theory (e.g., Beck et al., 2001), but within a neuropsychological cognitive framework as well. Further, if substantiated, the finding may help to explain why personality disorders, in general, have constantly been associated with poor prognostic outcomes. Traditional psychotherapies do not often assess or address accompanying neuropsychological dysfunction, especially more subtle cognitive dysfunctions.

3.4. Laboratory measures of working memory and personality disorders

Multiple regression analyses were performed for each of the 14 personality disorders (as individual dependent variables) and the four working memory measures (as independent variables), WAIS-III Digits Forward, WAIS-III Digits Backward, WAIS-III Letter–Number Sequencing, and OSPAN. The results of these analyses appear in Table 2. As can be seen in the table, 12 of the 14 personality disorder scales yielded significant regression equations. An

Table 1
Correlations of 14 CATI personality disorder scales and the CATI Executive Functions Deficits (EFD) scale.

Personality disorder scale	EFD scale
Antisocial	$.47^{***}$
Avoidant	$.48^{***}$
Borderline	$.40^{**}$
Dependent	$.35^{*}$
Depressive	$.42^{**}$
Histrionic	.10
Narcissistic	$.38^{**}$
Obsessive–compulsive	.10
Paranoid	$.41^{**}$
Passive–aggressive	$.65^{***}$
Schizotypal	$.47^{***}$
Schizoid	$.34^{*}$
Sadistic	$.44^{**}$
Self-Defeating	$.43^{**}$

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 2
A summary of multiple regressions for personality disorders and measures of working memory (WM) variables.

Pers. disorder	F	Sig.	R	R^2	Ad. R^2	WM variable	β	Sig.	WM variable	β	Sig.	WM variable	β	Sig.
Antisocial	0.34	.85	.17	.03	−.06									
Avoidant	4.17	.006	.53	.28	.21	Digits back	−.58	.003						
Borderline	1.48	.23	.35	.12	.04	Digits back	−.43	.04						
Dependent	1.42	.24	.34	.12	.04	Digits back	−.45	.03						
Depressive	3.91	.009	.52	.27	.20	Digits back	−.62	.002						
Histrionic	2.52	.055	.44	.19	.12	Digits back	−.47	.02	Digits forward	.40	.02			
Narcissistic	2.74	.04	.45	.20	.13	Digits back	−.56	.006						
Obsessive-Comp.	4.36	.005	.54	.29	.22	Digits forward	−.41	.009	Digits back	−.37	.046	Letter–Number	.37	.042
Paranoid	1.70	.17	.37	.14	.06	Digits back	−.42	.04						
Passive-Aggress.	3.10	.03	.47	.22	.15	Digits back	−.52	.008	Letter–Number	.40	.03			
Schizotypal	5.77	.001	.59	.35	.29	Digits back	−.55	.003	OSPAN	.28	.03			
Schizoid	5.05	.002	.57	.32	.26	Digits back	−.41	.03	OSPAN	.39	.004			
Sadistic	1.90	.13	.39	.15	.07									
Self-Defeating	2.65	.046	.45	.20	.12	Digits back	−.46	.02						

Note: WM independent variables included WAIS-III Digits Forward, WAIS-III Digits Backward, WAIS-III Letter–Number Sequencing, and OSPAN.

inspection of the β weights and their significance revealed a surprising finding; the Digits Backward subtest was significant and strongest in 11 of the 12 significant equations. In only one case was Digits Forwards stronger than Digits Backwards (obsessive–compulsive scale), and in that sole instance, the β weights were both significant and nearly equivalent. In no case was OSPAN stronger than Digits Backwards in the prediction of personality disorders, and it was only a significant predictor for two of the 12 personality disorder scales.

4. Discussion

The main hypothesis of this study was confirmed: of the 14 multiple regression equations, the Digits Backward task was the strongest and a significant predictor (in a negative direction) for 11 of the personality disorder scales. As noted previously, OSPAN, shown to be an excellent measure of general working memory capacity, was a significant predictor for only two of the 14 personality disorder scales, and in both cases was second strongest to Digits Backward. Also, as specifically hypothesized, the Borderline, Histrionic, and Schizoid personality disorder scales had Digits Backwards task as their strongest predictor.

With regard to executive function deficits, the previous findings by Coolidge et al. (2004) of child and adolescent twins were confirmed: executive function deficits appear to be positively correlated with nearly all of the *DSM* personality disorders. Also noted previously, even cursory inspection of the *DSM-IV-TR* criteria reveals significant overlap between at least five personality disorders with classic executive function deficits of the frontal lobes. It has already been well established that executive function deficits are important or even viewed as core deficits in some syndromes such as attention deficit hyperactivity disorder, autism (e.g., Pennington & Ozonoff, 1996), and school bullies (Coolidge et al., 2004). A deficit in the central executive component has also been viewed as a core deficit in schizophrenia (Kim, Glahn, Nuechterlein, & Cannon, 2004), so the strength of the relationship between executive function deficits and personality disorder features in the present study should not be surprising.

It was surprising that the inverse relationship between Digits Backwards capacity and nearly all of the personality disorder scales was so strong. None of the measures of the various components of working memory in the present study predicted personality disorders as well as performance on the Digits Backwards tasks. It is tempting to hypothesize that reduced Digits Backwards capacity could have a causal relationship with personality disorders, that is, reduced phonological storage capacity may indicate a kind of "restriction" of inner speech. A reduced capacity for inner speech may be indicative of an incapacity to evaluate alternative ways of solving interpersonal problems. As noted earlier, one function of Baddeley's proposed episodic buffer is to create alternative models of the environment that can be used to solve problems and make plans for future options. Perhaps, a restriction on inner speech, thus, limits either the production of alternative ways of behaving and/or restricts the ability to evaluate and select among alternative options. It is important to note, however, that it is not merely phonological storage capacity that may be correlated in some fashion to the maintenance of personality disorders but it seems likely that phonological storage capacity matters when it is tapping functions of the central executive. In addition, although the OSPAN task has been demonstrated to involve inhibition of pre-potent responses, so has Digit Backwards (e.g., Thomas et al., 2003).

It is also possible that Digits Backwards is a better measure of the inhibition of maladaptive core beliefs, as the OSPAN task also requires mathematical operations. It is also possible that Digits Backwards is a stronger measure of inhibition of pre-potent responses than OSPAN for the following reason: the way in which all people learn to speak. Universally, children learn to repeat words and phrases they hear, in the exact order of presentation. Thus, the strongly pre-potent response to repeat numbers in the order they were presented must be inhibited in the Digits Backwards task. The numbers in the Digits Backwards task must also be maintained in active working memory and also updated and reorganized into reverse order. The latter functions, of course, require central executive control. Is it possible, by processes suggested by Schmeichel (2007), that executive control for inhibition is being depleted by the demands of genetically controlled powerful predispositions to exaggerate or dramatize one's emotions (as in Cluster B personality disorders [antisocial, borderline, histrionic, narcissistic]) or to overly control them (as in some Cluster A [paranoid, schizoid] and Cluster C [obsessive–compulsive] personality disorders)?

Further theoretical support for the above hypothesis comes from the four categories of personality disorder symptoms proffered by *DSM-IV-TR*, cognition, affectivity, interpersonal functioning, and impulse control. If indeed, a reduced capacity for inner speech is a core deficit in personality disorders, then strong genetic predispositions to act in maladaptive ways has a negative synergistic effect: executive control to inhibit maladaptive predispositions is reduced, there is already a pre-existing reduction in the ability to "hold in mind" alternative ways of acting, and thus, subsequent negative reactions from others in interpersonal interactions may produce a "perfect storm" of negative consequences, and ultimately the highly maladaptive and chronic behaviors observed in personality disorders.

The present study has a number of limitations, the most cogent of which would be the sample size and use of a relatively young and homogeneous, nonclinical sample of convenience. Cursory inspection of the personality disorder scales in the present sample did reveal substantial variation and many clinical elevations for all of the 14 personality disorder scales; however, this does not obviate the need for replication of the present findings in clinical samples and with other of measures of executive functions and working memory. Additional research should be encouraged into the reputed relationship between phonological storage capacity and maladaptive core beliefs. It is important to note, as a kind of caution, that there is some danger in narrow definitions of executive functions. There is still some residual bias in the neuropsychological research that executive function measures are strictly cognitive, while there is much evidence to suggest executive function deficits may manifest themselves in many social and interpersonal ways and along different neural pathways than classic cognitive executive functions (e.g., Gazzaniga, Ivry, & Mangun, 2002). Given the undeniable role of inner speech to thinking and subsequent behavior and given the purported role of maladaptive core beliefs in the creation and maintenance of personality disorders, it is possible that phonological storage capacity, working memory capacity, and executive control functions may interact to play critical roles as well. Certainly, the interplay of these phenomena are worthy of further investigation.

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