Self-Control and Attention-Deficit Hyperactivity Disorder:

Individual Differences in Ego Depletion in a University Sample

by

Andrew A. Lubusko

A dissertation

presented to the University of Manitoba

in partial fulfillment of

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in

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FACULTY OF GRADUATE STUDIES

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ABSTRACT

Self-control (e.g., impulse control) is a key human ability that is linked to adaptive functioning and success. Conversely, poor self-control is associated with numerous interpersonal difficulties (e.g., academic failure, addictions). Recent research by Baumeister, Muraven, and colleagues suggests that self-control works similar to a muscle: the exertion of self-control on a task leads to temporary fatigue and failure on subsequent self-control tasks. The term ego depletion has been used to describe this phenomenon. The current study attempted to extend ego depletion research into the clinical realm by including participants with self-control difficulties. Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder of self-control characterized by disinhibition and inattention. Participants included 108 university students (54 with reported childhood and ongoing adult ADHD symptoms, and 54 matched peers) who completed either a Depletion (computerized self-control task)or Non-Depletion (arithmetic questions) task and a subsequent battery of tests sensitive to ego depletion and self-control. It was hypothesized that ADHD participants would exhibit significantly more ego depletion than Non-ADHD participants on a handgrip stamina task (HG) and a computerized gambling task (GT). Contrary to hypotheses, ADHD participants did not show the expected ego depletion effect on the HG or GT. Results of the study suggest alternate theoretical models to understand the performance of ADHD participants. These models include over-depletion (i.e., ADHD participants were too depleted to show ego depletion), resource conservation (i.e., ADHD participants

inappropriatly conserved resources, leading to decreased ego depletion), or inattention (i.e., characteristics of ADHD, like inattention, interfered with ego depletion).

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INTRODUCTION

All of us are familiar with terms such as *willpower*, *self-control*, and *self-discipline*. These terms imply that there is a kind of self-control *strength* that people possess or can develop and that this strength can be used to help people attain personal goals and standards (Baumeister, 2001; Baumeister, Heatherton, & Tice, 1994; Muraven & Baumeister, 2000). Moreover, the terms associated with self-control imply that the process of attaining one's goals requires *effort* or *hard work* in order to *resist temptation*, *delay gratification*, *inhibit impulses*, and *maintain persistence*. Individuals with good self-control are seen as *strong*, *effective*, and having *moral character*; and individuals who lack self-control are viewed as *weak*, *ineffective*, or *sinful* (Baumeister & Exline, 2000; Goleman, 1995). Self-control is associated with success (e.g., academic, vocational, and financial) and overall physical and psychological health (Baumeister et al., 1994; Goleman, 1995; Strayhorn, 2002). Conversely, lack of self-control is linked to many psychosocial difficulties such as crime, alcohol and drug addiction, academic and vocational underachievement, unhealthy lifestyles and obesity.

Understanding how self-control operates and identifying individuals with strengths and weaknesses in self-control are important areas of psychological inquiry. Preliminary research in this area by Baumeister, Muraven, and colleagues (Baumeister, 2000; 2001; Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven & Baumeister, 2000; Muraven, Baumeister, & Tice, 1999; Muraven, Tice, & Baumeister, 1998) suggests that (1) self-control operates like a muscle and (2) the exertion of self-control depletes energy resources and leads to subsequent self-control failure. The term *ego depletion* has been used to describe this phenomenon (Baumeister et al., 1998). The ego depletion phenomenon is important because it suggests that situational factors can influence self-control and that individuals may vary in self-control strength.

The goal of the current study was to extend the previous research on self-control strength and ego depletion by testing the theory in individuals identified as having self-control difficulties. The primary aim of the study was to determine if individuals with symptoms of *Attention-Deficit/Hyperactivity Disorder* (ADHD) exhibit more ego depletion than individuals without ADHD symptoms. ADHD is a neurodevelopmental disorder of self-control characterized by significant difficulties with attention, impulse control, and hyperactivity (American Psychiatric Association [APA], 1994). ADHD affects millions of children and adults in North America and is one of the main developmental disorders assessed and diagnosed in childhood. Individuals diagnosed with ADHD struggle with lifelong difficulties in impulse control; underachievement in academic and vocational settings; strained interpersonal relationships; and increased risks for depression, conduct disorders, addictions, and criminal behaviour (Barkley; 1997; 1998; Dale & Baumeister, 1999; Goldstein, 1997; 2002; Weiss, Hechtman, & Weiss, 1999; Wender, 2000). Extension of the self-control strength model to ADHD was seen as important in terms of adding support to the model and increasing our understanding of ADHD.

SELF-CONTROL

The current chapter highlights some of the current definitions, key concepts and theories of self-control and self-control failure. The strength model of volitional self-control and background on ADHD are addressed in subsequent chapters. The history of self-control is outside the scope of the current document (see Barkley, 1997; Baumeister & Heatherton, 1996; Baumeister et al., 1994; Rachlin, 2000; Strayhorn, 2002).

The Importance of Self-Control in Everyday Life

Examples of self-control in everyday life are numerous. We exert self-control when we get out of bed early in the morning as opposed to sleeping late; when we go to bed early instead of staying up late; when we refrain from the pleasures offered by junk food, alcohol, drugs, gambling, and sex; when we save money; when we set and work toward long-term goals; when we calm down in the face of frustration versus becoming angry; when we tolerate the opinions of others who annoy us; when we force ourselves to persist on tasks despite feeling tired, anxious, discouraged, or unmotivated; when we go to meetings or appointments that we would rather miss; when we engage in an exercise program or follow a healthy diet; when we try to live our lives according to ethical or moral standards; and when we try to overcome bad habits and addictions (Baumeister et al., 1994; Muraven & Baumeister, 2000; Strayhorn, 2002).

As noted above, self-control is associated with academic and vocational success, financial security, and overall physical and mental health (Baumeister et al., 1994; Muraven & Baumeister, 2000; Strayhorn, 2002). At times, self-control may be even more important than ability (Baumeister et al., 1994; Boyatzis, Goleman, & Rhee, 2000; Goleman, 1995). For example, individuals with moderate ability or talent—but with strong self-control skills (e.g., organized, hard working, able to set and meet realistic goals)—may be more successful academically or vocationally than peers who are more talented but who have less self-control (Baumeister et al., 1994).

Conversely, self-control failure underlies many of the psychosocial problems that plague modern society. Poor self-control has been linked to psychological and social difficulties such as alcoholism and substance abuse, pathological gambling, crime, personal bankruptcy (e.g., impulsive spending, poor self-monitoring of finances), eating disorders, divorce, sexually transmitted diseases (e.g., promiscuous behaviour, not using proper protection), academic underachievement (e.g., procrastination), and poor health (e.g., lack of exercise, poor diet) (Baumeister & Exline, 2000; Baumeister & Heatherton, 1996; Baumeister et al., 1994; Dale & Baumeister, 1999; Muraven & Baumeister, 2000; Rachlin, 2000; Strayhorn, 2002). Moreover, self-control failure is seen as a key factor in various forms of psychopathology such as anxiety; depression and suicide; alcoholism and other substance abuse; eating disorders; somatoform disorders; antisocial, borderline, and histrionic personality disorders; and developmental disorders such as ADHD, oppositional, and conduct disorders (Barkley, 1997; Baumeister & Heatherton, 1996; Baumeister et al., 1994; Blum et al., 2000; Dale & Baumeister, 1999; Gruber, 1987; Gschwandtner, Aston, Renaud, & Fuhr, 2001; Mahoney, 1991; Rachlin, 2000; Strayhorn, 2002; Tangney, Baumeister, & Boone, 2004; Taylor, 2001; Vohs & Baumeister, 2000).

Definitions of Self-Control

In the theoretical and research literature, *self-control* is a strength-like character trait or ability that allows individuals to attain personal goals (Baumeister et al., 1994;

Strayhorn, 2002) and the specific actions (i.e., overt or covert behaviours) that individuals perform in order to attain goals (Barkley, 1997; Baumeister & Exline, 2000). Self-control involves setting goals, altering one's self (e.g., overriding emotions, inhibiting impulses) or one's environment (e.g., removing distractions or temptations) to attain the goals, monitoring one's progress toward the goals, and sustaining effort until the goals are reached (Barkley, 1997; Baumeister, 2000; 2001; Baumeister & Exline, 2000; Muraven & Baumeister, 2000). Terms and constructs linked to self-control include *delay of gratification* (waiting for a valuable reward; Mischel & Ayduk, 2004; Mischel, Shoda, & Rodriguez, 1989; Rodriguez, Mischel, & Shoda, 1989), *learned industriousness* (putting in effort in order to achieve a reward; Eisenberger, 1992), *conscience* (following moral rules and resisting temptation to receive a reward; Kochanska, 1997), *behavioural inhibition* and *impulse control* (inhibiting prepotent responses when facing immediate reinforcement; Barkley, 1997), *ability to remember the future* (ability to think about the consequence of actions; Maté, 1999; Strayhorn, 2002), and "the ability to think about the future and plan accordingly" (Pinker, 1997, p. 393). All of these terms and constructs "involve doing something less immediately pleasurable than an alternative, because it has a greater total expected benefit or is more ethical" (Strayhorn, 2002, p. 7).

Baumeister, Heatherton, and Tice (1994) define self-control broadly as

> . . . any effort by a human being to alter its own responses. The responses may include actions, thoughts, feelings, desires, and performances. In the absence of regulation, the person would respond to the particular situation in a certain way, whether because of learning, habit, inclination, or even innate tendencies. Self-regulation [or self-control] prevents this normal or natural response from occurring and substitutes another response (or lack of response) in its place. (p. 7)

They also highlight the fact that self-control is involved when people respond in a *conscious* or *controlled* manner—as opposed to when they respond *automatically.*

The Ingredients of Self-Control

Barkley (1997) defines self-control as "any response or chain of responses by the individual which serve to alter the probability of their subsequent response to an event and, in doing so, function to alter the probability of a later consequence related to that event" (p. 51). This definition contains six important ingredients: (1) *The responses by the individual are directed at modifying the individual's own behaviour or his/her environment*, rather than at the environmental event that may have initiated them (e.g., removing a box of candy from a room). (2) *The actions are designed to alter the probability of a subsequent response by the individual* (e.g., decrease the probability of eating the candy). (3) *Self-control actions function to change later as opposed to immediate outcomes* and are aimed at achieving a net maximization of beneficial consequences across immediate and distal outcomes (e.g., the immediate pleasure of eating candy is sacrificed for a more desirable goal of losing weight). (4) *Self-control requires that the individual has developed a preference for the long-term as opposed to the short-term outcomes of behaviour:* this involves both developmental changes (e.g., the maturation of the frontal lobes and the development of inhibition) *and* motivational changes (e.g., developing a preference for larger long-term goals).[1] (5) *Self-control actions bridge the time delays across the elements that comprise behavioural contingencies:* self-regulation is required in situations when there is a conflict between immediate and delayed goals (e.g., candy now versus weight loss later) and often requires

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[1] A preference for immediate gratification may be adaptive in some environments (Pinker, 1997). For example, if one lives in a dangerous environment and faces a short lifespan (e.g., a high-crime neighborhood), it may be more adaptive to maximize immediate goals over long-term ones.

a capacity for cross-temporal organization of behavioural contingencies (e.g., the ability to make concrete plans regarding how one will deal with candy and other reinforcers). (6) *Self-control requires the capacity to sense time and the future and to put them to use in the organization and execution of behaviour:* the ability to anticipate, prepare for, and respond to future events requires an intact working memory that holds "in-mind" past information, goals, plans, and temporal sequences.

Types of Self-Control

Research has primarily focused on four main categories of self-control: (1) *impulse control,* resisting temptations and refraining from acting on undesirable impulses such as overeating, aggression, etc.; (2) *thought control,* concentrating, regulating one's reasoning or inference process, or suppressing unwanted thoughts; (3) *affect regulation,* efforts aimed at altering one's emotional and mood states (e.g., escaping negative mood or maintaining positive mood); and (4) *achieving optimal performance* and *controlling performance* through efforts such as persistence, optimal management of exertion, and balancing speed and accuracy (Baumeister & Exline, 2000). The four categories highlight the importance of self-control in human life and suggest that self-control plays a key role in our emotional wellbeing and other forms of success.

Key Concepts in Self-Control Theory

Self-control is a complex construct that involves numerous concepts. Some of the key concepts in self-control theory include delay of gratification, feedback loops and the cybernetic model, the distinction between automatic and controlled processes, impulse control, self-efficacy and learned helplessness, and executive functioning.

Delay of Gratification in Children

Delay of gratification—postponing a small immediate reward in favor of a larger later reward—is a key example of self-control. Research by Mischel and colleagues in the 1960s on delay of gratification in children (see Mischel et al., 1989 for a review) highlights the importance of this construct. The research paradigm included a situation where a child was given the choice to end a wait of undetermined amount of time for a less-preferred object (one marshmallow) or to wait for the researcher to return for a more preferred object (two marshmallows). Mischel and colleagues examined long-term outcomes of children's ability to generate effective self-control strategies in several longitudinal studies. For example, Shoda, Mischel, and Peake (1990) followed-up on adolescents who, as children, had been tested in four versions of the delay of gratification task (e.g., object *visible* vs. *hidden*, and self-control strategy *suggested* vs. *spontaneous*). The follow-up included 185 of the original 653 children tested. The only condition that predicted later adjustment was the most difficult one—the one in which the children were faced with visible rewards and had to generate their own self-control strategies. Preschoolers who were able to delay gratification for longer periods of time in this condition were later found, as adolescents, to have higher levels of self-control, concentration, and motivation, and higher *Scholastic Aptitude Test* (SAT) scores.

Feedback Loops and the Cybernetic Model

Feedback loops—cycles by which a system adjusts its behaviour in response to the current state of the system—are key processes in self-organizing/self-regulating systems (Mahoney, 1991). The thermostat is an example of a cybernetic feedback loop system: It assesses current conditions (current temperature), compares these to a *goal* (ideal temperature), and then *responds* in a way to meet this goal (by turning on the air conditioning if the current temperature is warmer than the ideal temperature). Powers (1973) and, more recently, Carver and Scheier (Carve & Scheier; 1981; 1996; 1998) have applied the cybernetic model to the study of self-control. The model proposed by Carver and Scheier consists of four components, summarized by the acronym *TOTE*: (1) *Test*, (2) *Operate*, (3) *Test*, and (4) *Exit*. The TOTE cycle refers to the control or regulatory processes in which the self compares itself against a relevant standard or goal (e.g., ideal weight), operates on itself to reduce any discrepancies (e.g., if the weight is higher than ideal, the self takes steps to lose weight), tests again (e.g., re-checks weight), continues the process until a test reveals the standard has been reached, and then exits the cycle. In the cybernetic model proposed by Carver and Scheir, self-control consists of a hierarchy of goal-oriented feedback loops where superordinate goals (e.g., being a responsible person) control subordinate goals (e.g., taking a package to a friend, driving a car to the friend's home, using the physical mechanics of driving the car; Carver & Scheier, 1998).

Self-Awareness and Self-Monitoring

Self-awareness and *self-monitoring*, which play key roles in self-control, are associated with the test phases of the TOTE cycle (Carver & Scheier, 1981). Self-awareness enables the self to appraise where it is in relation to where it wants to be, so as to facilitate progress toward personal goals. Situations that impede self-awareness often foster self-control failure (Baumeister et al., 1994; Heatherton & Baumeister, 1996; Heatherton, Polivy, Herman, & Baumeister, 1993). For example, Heatherton et al. (1993) manipulated self-awareness among groups of dieters (i.e., retrained eaters) and control participants, and found that decreased self-awareness led to increased eating behaviour in the restrained eaters group. Control participants, who were not monitoring their eating habits, were unaffected by the manipulation.

The Importance of Goals

Setting and meeting realistic goals or other personal standards is essential to self-control: "Goals (or other standards) are a prerequisite for effective self-regulation, and . . . a lack of goals will make self-regulation ineffective or even impossible" (Baumeister et al., 1994, p. 62). In their review of self-control failures, Baumeister et al. argue that people are most likely to fail at self-control when they fail to set goals or when they set unrealistic, unreachable goals (e.g., an alcoholic vows *never* drink alcohol again). Setting unreachable goals may make people vulnerable to *lapse-activated self-regulation failure,* in which people forgo self-control after failing at unreasonable goals (Baumeister & Heatherton, 1996; Baumeister et al., 1994). In other words, setting an unreachable goal and then experiencing a mild setback may lead a person to "give up" on self-control and further engage in unwanted behaviour.

Control of attention, directing one's attention toward goals and being able to sustain attention, is another key factor related to both goal-setting and self-monitoring (Barkley, 1997; Baumeister & Heatherton, 1996; Baumeister et al., 1994; Strayhorn, 2002). Losing focus of one's goals or the task at hand can lead individuals to lose self-control on effortful tasks (Baumeister et al., 1994). This is especially true when people become anxious or otherwise distressed and start to focus on personal shortcomings as opposed to the goal-oriented task.

Cognitive-Affective Processing System

Mischel and colleagues (e.g., Mischel & Ayduk, 2004) have proposed a self-control feedback model based on their delay of gratification research. Their *cognitive-affective processing system* (CAPS) model has two parallel processes: a *hot* process that is well-developed at birth and acts very quickly in response to stimuli (e.g., immediate gratification) and a *cold* process that matures slowly and responds in a more planned and careful manner (e.g., delayed gratification). Hot processes are primarily affective and analogous to Freud's concept of the id; cool processes are cognitive and analogous to Freud's concept of the ego. Both processes are needed to work toward goals, meet needs, and make decisions. The two processes interconnect through a system of excitatory or inhibitory cognitive-affective units. Hot processes ensure goal-motivation; cool processes temper the motivation away from immediate goals and toward distant or greater ones. For example, in the delay of gratification studies, hot processes were activated by having the children be able to see their rewards (candy) and cold processes were activated when the children used cognitive strategies to temper their immediate gratification (e.g., telling themselves that the candies were made of plastic). Hot processes are automatic; cool ones require conscious effort and only become automatic through experience, learning, and practice. Hot processes are hypothesized to be linked to the amygdala (i.e., emotion) and cold processes to the ventromedial frontal lobes (i.e., planning, executive functioning). The CAPS is a feedback loop in that the system is continually updated with new data (e.g., if one's behaviour changes one's environment, information about the environment triggers different hot or cold processes). Individual differences (e.g., in attention control) are hypothesized to play an important role in self-control.

Automatic Versus Controlled Processes

A growing body of evidence suggests that most of our behaviour is controlled by environmental stimuli and automatic processes (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000; Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001; Fitzsimons & Bargh, 2004).[2] Automatic processes are efficient: they use less system resources than

[2]Bargh and colleagues argue that *all* behaviour (including higher-order processes)

conscious or controlled processes. Most behaviours, while initially consciously learned, automate over time (e.g., playing the piano, riding a bicycle). Controlled or conscious processes (which overlap with executive functions; see below) are hypothesized to play a key role in self-control. Using the analogy of a car driving down a highway, Baumeister (2001) suggests that most of the time the car is driving via automatic processes—down a straight road—and that occasionally conscious/controlled processes come into play—such as when the car is required to turn or respond to novel circumstances. Although used sporadically, these controlled processes play a key role in overall functioning.

Impulse Control and Acquiescence

Terms such as *impulse control* and *self-control* are often used synonymously in the research literature. Baumeister et al. (1994) offer a precise definition of *impulse* as "a specific motivation or desire to perform a particular action [here-and-now], as opposed to a general or latent desire or a trait" (p. 132). They suggest three concepts necessary to the understanding of impulses: a *latent motivation*, a general desire or want; an *activating stimulus*, something in the immediate situation (temptation) that is relevant to the latent motivation; and the *impulse* itself, arising from the interaction of the latent motivation and the activating stimulus. They also note that the term "impulse control" is a misnomer in that an impulse (desire) itself generally cannot be prevented from arising; however, what can be controlled is how one responds to the impulse.

Finally, Baumeister et al. (1994) suggest that individuals overestimate or rationalize the power of impulses and addictions in their lives. For example, individuals may say that they have "no control" over certain impulses. Moreover, individuals likely

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is automatic and that consciousness is essentially an epiphenomenon). Although Bargh's view is controversial, there is general consensus that automatic processes underlie the majority of our behaviour (Baumeister, 2001; Stuss & Levine, 2002).

acquiesce to their impulses. Although "people may experience strong and persistent cravings [e.g., for eating ice cream]. . . . if those indulgences are out of control, it is very likely because the person gives himself or herself permission to indulge them" (p. 134). In other words, most impulses are likely not so strong that they control all bodily movements (e.g., opening the fridge, taking out the ice cream container, opening it).

Self-Efficacy and Learned Helplessness

The construct of *self-efficacy,* one's belief that one can accomplish tasks successfully, is as another key component in self-control, effective performance, and overall well-being (Bandura, 1977; 1989; 1996). Individuals' self-efficacy determines both their self-control and their adoption of self-control strategies. For example, if individuals feel competent in their self-control abilities, they will be more likely to engage in self-control activities. Moreover, Bandura's (1996) expanded model of "human agency" proposes that self-efficacy bridges the gap between thinking and doing.

Seligman's (1975; 1994) work on *learned helplessness* suggests that experiences with uncontrollable negative events and previous self-control failure can cause people to feel helpless and powerless, develop negative self-esteem and depression, and be more prone to give up on self-regulation. People may see themselves as helpless and may exert less effort in self-control activities that could improve their well-being and self-worth. Moreover, failure may lead people to focus on feelings of anxiety and low self-worth—as opposed to focusing on attending to their goals.

Underregulation and Misregulation

Two forms of self-control have been studied in the literature: *underregulation*, the failure to exert sufficient self-control, and *misregulation*, the exertion of inappropriate or ineffective self-control strategies (Baumeister & Heatherton, 1996; Baumeister et al., 1994; Rachlin, 2000). In misregulation, individuals apply strategies that lead to decreased self-control. The idea that an alcoholic tries to improve (i.e., control) a negative mood by drinking alcohol, which ultimately leads to an even lower mood, is an example of misregulation (see Rachlin, 2000 for a review).

General Factors that Limit Self-Control

Self-control failure is associated with factors that limit or interfere with self-awareness and self-monitoring. Some of the factors that interfere with self-awareness/ self-monitoring and self-control include fatigue, stress and emotional distress, and cognitive load.

Self-control failures are more likely to occur when people are tired (Baumeister & Heatherton, 1996; Baumeister et al., 1994; Muraven & Baumeister, 2000). *Fatigue* likely decreases self-awareness/self-monitoring and in turn increases self-control failure. Despite the importance of fatigue in self-control, little attention has been paid to the effect of fatigue in learning/behavioural and mathematical models of self-control (Pear, 2001). As will be discussed further in the next chapter, the importance of fatigue is addressed in the self-control strength model proposed by Baumeister and colleagues.

Stress and emotional distress (e.g., anxiety, depression) are associated with self-control failure (Baumeister & Heatherton, 1996; Baumeister et al., 1994; Muraven & Baumeister, 2000). Stress depletes energy resources, leads to superficial information processing (i.e., increase of judgment and planning errors), and is associated with decreased frustration tolerance, decreased persistence, and increased quitting. Similarly, anxiety and depression focus attention away from tasks and goals and onto personal shortcomings, which in turn serves to decrease persistence and increase self-control failure (Baumeister & Heatherton, 1996; Baumeister et al., 1994).

Cognitive load is another factor—related to stress on information-processing and attentional systems—that can cause fatigue and interfere with self-awareness and self-monitoring (Ward & Mann, 2000). Two recent studies by Ward and Mann demonstrated that performing high cognitive-load tasks led restrained eaters (i.e., individuals dieting or monitoring their calorie intake) to consume higher amounts of high-calorie food. The disinhibition effect stems from the fact that cognitive load interferes with the restrained eater's ability to monitor the consequences of their eating behaviour.

Frontal Lobes and Executive Functioning

Self-control is related to the multidimensional construct of *executive functioning,* a set of neuropsychological functions, abilities, and self-directed behaviours that underlie and promote effective, socially responsible, goal-oriented behaviour (Barkley, 1997; Banfield, Wyland, Macrae, Münte, & Heatherton, 2004; Baumeister, 2000; Lezak, 1995; Stuss & Levine, 2002). The major executive functions include *volition* (determining goals and conceptualizing future realizations of goals), *planning* (identifying and organizing steps and elements needed to achieve goals), *purposive action* (translation of intentions or plans into productive, self-serving activities), and *effective performance* (utilization of self-monitoring and self-correction in order to fine-tune performance; Lezak, 1995, pp. 651-674). In brief, "executive functions are those types of actions we perform to ourselves and direct at ourselves so as to accomplish self-control, goal-directed behaviour, and the maximization of future outcomes" (Barkley, 1997, p. 57). The current section highlights the importance and evolution of the frontal lobes and executive functioning; key functions and abilities, such as self-awareness, behavioural inhibition, working memory and attention, and planning; and self-control deficits associated with frontal lobe dysfunction.

The Evolution of Self-Control

Compared to other animal species, human beings have a better-developed and more powerful ability to engage in self-control (Banfield et al., 2004; Baumeister & Exline, 2000). Self-control allows human beings to adjust to a variety of natural and social situations. Compared to other species, humans have a wider range of behaviour and adaptations, and the capacity for self-control has likely played a key role in this success. The frontal lobes, which underpin self-control and other executive functions, evolved relatively recently in human history and are larger in humans than in other mammals (Absher & Cummings, 1995; Mahoney, 1991; Stuss, Gow, & Hetherington, 1992; Stuss & Levine, 2002). The evolutionary recency is seen by the fact that frontal lobes mature more slowly than other brain regions (paralleling the gradual increase in self-control with age and maturity) and by the fact that executive functions are relatively fragile (i.e., easily disrupted by brain damage; Absher & Cummings, 1995; Barkley, 2001; Baumeister & Exline, 2000; Mahoney, 1991; Pinker, 1997). The frontal lobes and executive functions likely evolved in response to increased interpersonal competition as human behaviour and interaction began to involve larger and more integrated social groups (Barkley, 2001; Baumeister & Exline, 2000; Pinker, 1997). Executive functioning allows individuals to stop and think as opposed to reacting automatically and to covertly analyze "internal representations" (i.e., memories, plans, goals, etc.) in purposive action.[3]

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[3] The programming functions of purposive action play key roles in tasks that are novel, non-routine, and deliberate (Lezak, 1995). In the context of the self-control strength model, purposive action requires and uses volitional/executive energy resources (Baumeister, Muraven, & Tice, 2000; Muraven & Baumeister, 2000). Conversely, automatic behaviours and performance of tasks that are overlearned, familiar and routine require little if any of executive functioning resources.

Executive Functions

Barkley (1997) defines executive functions as the "self-directed actions [most of which are private or covert] of the individual that are being used to self-regulate" (p. 56). Executive functioning arises from the (1) maturation and development of neural networks in the prefrontal lobes, which underlie executive abilities and permit the acquisition of self-control skills; (2) past success that self-directed actions have had maximizing net consequences of behaviour (i.e., reinforcement for persistence, delay of gratification); (3) socialization of the child; and (4) ongoing reinforcement of the individual for using self-control actions (p. 56). Key executive functions include self-awareness, behavioural inhibition, working memory, planning ability, and attentional control (Banfield et al., 2004; Barkley, 1997; 2001; Denckla, 1996; Lezak, 1995; Stuss & Levine, 2002).

Self-awareness, awareness of oneself (i.e., current situation, location, intentions), is a key executive function that facilitates other executive functions (Denckla, 1996). Self-awareness is important in volition, planning, purposive action, and effective performance (Lezak, 1995), and lack of self-awareness is linked to self-control failure (Baumeister et al., 1994). Current evidence suggests that self-awareness is mediated by the frontal lobes (Stuss & Levine, 2002).

Behavioural inhibition is a central executive function in Barkey's (1997; 2001) multidimensional self-control model of ADHD. In the model, behavioural inhibition includes three functions/abilities: *inhibition of prepotent responses* (prevent automatic/ motivated behaviour), *interruption of ongoing responses* (to stop automatic/motivated behaviour), and *interference control* (persist in a response when faced with competing stimuli or behaviours). Behavioural inhibition underlies other executive functions such as *nonverbal working memory* (holding events in mind, self-awareness, hindsight, forethought), *verbal working memory* (self-questioning/problem solving, rule-governed behaviour, moral reasoning), *emotional/motivational self-regulation* (perspective taking; self-regulation of affect, motivation, arousal), and *reconstitution* (verbal and behavioural fluency, analysis and synthesis of behaviour). Those executive functions then control *motor performance* (execution of goal-directed responses, goal-directed persistence, sensitivity to response feedback, task-re-engagement following disruption, and control of behaviour by internally represented information).

Planning is another key executive function (Barkley, 1997; 2001; Lezak, 1995; Stuss & Levine, 2002). Planning requires the mental or imaginary time travel and the organization of behaviour across time (Barkley, 1997; 2001; Stuss & Levine, 2002). Planning requires us to remember past information (e.g., previous situations that helped or hindered goal-directed behaviour), current goals, and plans, and to use this information to create mental representations (i.e., hypotheses) of future events and appropriate behavioural contingencies.

Other models of self-control and executive functioning stress the role of *working memory* and attentional processes (Baddeley, 1996; Baumeister & Heatherton, 1996; Baumeister et al., 1994). Planning, mental representation, processing information, etc., requires intact working memory, a neuropsychological function that both stores (i.e., holds "in-mind" or "on-line") *and* processes information.

Attentional control—being able to direct attention (e.g., focus on tasks/goals) and to sustain attention (i.e., vigilance)—has also been postulated as a central executive process (Baumeister & Heatherton, 1996; Baumeister et al., 1994; Brown, 1995a, 1995b; Strayhorn, 2002). Poor management of attention associates with self-control failure (e.g., lapse-activated self-control failure; Baumeister & Heatherton, 1996; Baumeister et al., 1994). Conversely, effortful attention (e.g., focusing on a task, combating negative thinking) strengthens positive automatic thoughts and can help focus on long-term goals and encourage persistence on difficult, effortful, and boring tasks.

Intelligence and Executive Functioning

The relationship between executive functioning and intellectual functioning (IQ) is unclear. Some research (e.g., Mischel et al., 1989; Rodriguez et al., 1989) suggests that self-control in children correlates with later life academic/intellectual performance (i.e., SAT scores). Similarly, executive functioning in individuals with ADHD correlates moderately with intelligence as measured by standardized IQ tests (Barkley, 1997; Murphy, Barkley, & Bush, 2001). Nevertheless, it is not uncommon for individuals with "real life" self-control difficulties (e.g., ADHD) to exhibit normal IQ test performance (Bechara, Tranel, & Damasio, 2000; Tulsky, Zhu, & Ledbetter, 1997).[4] The low correlation between IQ and executive functioning can be explained by the fact that IQ tests generally assess well-learned automatic problem-solving and memory processes, which are generally unimpaired (Barkley, 1997; Murphy et al., 2001; Paule et al., 2000; Strayhorn, 2002). Conversely, executive functioning and self-control are better tapped by tasks that are novel and that require effort and inhibition.

In his review of *emotional intelligence,* in which self-control plays a central role, Goleman (1995) suggests that intelligence is a "baseline" or "necessary precondition" for success (e.g., academic or vocational success) and that self-control plays an auxiliary role.[5] For example, in a group of health professionals, all of whom have high intelligence

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4 The impairment that individuals with ADHD exhibit on IQ tests is primarily in the domains of working memory and processing speed, both of which are associated with attentional and executive functioning type abilities (Tulsky et al., 1997).

5 Emotional intelligence (EI) is a multidimensional construct that overlaps with self-regulation and executive functioning, and refers to interpersonal traits and abilities.

(necessary precondition), the most successful (e.g., financially) might be the ones with the greatest levels of self-control (Boyatzis et al., 2000).

Frontal Lobe Dysfunction

Patients with frontal lobe lesions to the ventral prefrontal cortex (VPFC)—which assists in maintenance, interference control, inhibition, and emotional processing—exhibit difficulties in decision-making (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, Damasio, & Damasio, 2000; Bechara, Tranel et al., 2000), self-regulation (Stuss et al., 1992; Stuss & Levine, 2002), and "executive" neuropsychological functioning (Barkley, 1997; Denckla, 1996; Fisher, 1998). Individuals with VPFC lesions exhibit difficulties on higher-level decision-making tasks involving reinforcement and punishment in novel, unstructured situations (Bechara et al., 1994; Bechara, Damasio et al., 2000; Bechara, Tranel et al., 2000) such as the Gambling Task (GT) developed by Bechara and colleagues (Bechara et al., 1994). The GT requires an individual to take 100 cards from one of four decks of cards in order to "win the most money possible." Unknown to the individual, the decks differ in reinforcement schedules. Two of the decks are disadvantageous (high reward, high punishment) and two are advantageous (moderate reward, low punishment). While normal control subjects quickly learn which decks are advantageous, individuals with VPFC lesions fail to learn and keep choosing from the disadvantageous decks.

The impairment of VPFC patients on the GT has been interpreted in terms of the *somatic marker hypothesis* (Damasio, 1995; 1996; 1998a; 1998b), which states that

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Individuals with high EI are hypothesized to have high self-control and impulse control, emotional self-awareness, stress tolerance, assertiveness, empathy, problem-solving skills, and social skills (Bar-On, 2000; Boyatzis et al., 2000). The deficits of individuals with low EI parallel the difficulties observed in individuals with frontal lobe disorders (FLD) and self-control disorders such as ADHD (Goleman, 1995; Maté, 1999).

somatic markers or body-state/emotional signals (e.g., increased skin conductance indicative of arousal), give *value* (positive or negative) to behaviours and choices and, as a result, guide behaviour and decision-making. Reinforcing/rewarding stimuli are linked to positive emotional states (positive somatic markers), and punishing stimuli are linked to negative emotional states (negative somatic markers).[6] In the model, poor performance on the GT indicates a failure to activate negative somatic markers when faced with stimuli that activate positive somatic markers (Bechara, Tranel et al., 2000; Damasio, 1995; 1998b). When faced with a high reward/high punishment deck, the individual the VPFC lesion focuses on the high reward and fails to recognize the risk of punishment.

Other difficulties observed with frontal lobe damage include: difficulty sustaining attention; automaticity; disinhibition, restlessness, and impulsivity; apathy and inertia (e.g., difficulty starting new behaviour or stopping ongoing behaviour); decreased initiative and motivation; affective dysregulation; decreased concern with social norms, immaturity, and childish behaviour; poor judgment and poor planning (e.g., inability to organize behaviour across time); and purposelessness (Absher & Cummings, 1995; Banfield et al., 2004; Barkley, 1997; Lezak, 1995; Stuss & Levine, 2002).

Individuals with VPFC injuries exhibit difficulties consistent with a *self-regulatory disorder,* "an inability to regulate behaviour according to internal goals and constraints . . . [caused by] the inability to hold a mental representation of the self on-line and to use this self-related information to inhibit inappropriate responses" (Stuss & Levine, 2002, p. 418). SRD difficulties are most apparent in unstructured or novel

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[6]The amygdala has a central role in establishing primary (i.e., biological) somatic markers, and parts of the frontal lobes (e.g., ventromedial prefrontal cortex) have key roles in establishing secondary (i.e., learned, higher-order, and abstract) somatic markers. Both amygdala and frontal lobe areas underlie impairments in developmental disorders of self-control such as ADHD (Barkley, 1997; Filipek et al., 1997; Stuss & Levine, 2002).

situations "in which patients fail to inhibit inappropriate responses in favor of those that might result in a preferential long-term outcome" (p. 418). As noted above, situations that are structured, involve unambiguous environmental cues, and over-learned/automatic responses are generally unimpaired. The deficits associated with SRD imply difficulties in working memory (i.e., difficulty holding information in-mind or on-line), insufficient self-monitoring or self-awareness, insufficient goals (or an inability to access/remember goals), and failure to weigh behavioural consequences.

Summary

The above sections highlight the importance of self-control in our lives. Good self-control is associated with numerous indicators of psychosocial health and lack of self-control/self-control failure is associated with numerous psychosocial difficulties. Self-control is a multidimensional construct that involves goals, feedback loops, automatic and controlled processes, and intact neurological brain structures (e.g., frontal lobes and executive functions). Self-control is strengthened by having clear and realistic goals, developing a preference for self-control, self-awareness, self-monitoring, and attentional control. Conversely, self-control is impeded by factors such as fatigue, stress, cognitive load, low self-efficacy and learned helplessness, and neurological damage. Research on self-control suggests that individuals vary in self-control strength and that numerous factors can affect self-control performance. The next section introduces the self-control strength model proposed by Baumeister, Muraven, and colleagues.

THE STRENGTH MODEL OF VOLITIONAL SELF-CONTROL

Preliminary research by Baumeister, Muraven, and colleagues (Baumeister, 2000; 2001; Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998) suggests that self-control operates like a muscle and that the exertion of self-control depletes energy resources and leads to subsequent self-control failure. Researchers have used the term *ego depletion* to describe this phenomenon. Ego depletion is important because it suggests that situational factors influence self-control and that individuals vary in self-control strength. The current chapter highlights the assumptions of the strength model, relevant research findings, and clinical implications.

Assumptions of the Strength Model

Muraven and Baumeister (2000) summarize the key assumptions of the strength model of volitional self-control: (1) All acts of volition and self-control (e.g., decision making, initiating and interrupting behaviour) require volitional self-control strength. (2) People have finite capacities for volitional self-control strength (they can only inhibit a finite number of urges at one time), and exertion can deplete this strength. (3) All self-control efforts draw on the same energy resource (i.e., directing volitional self-control efforts toward one goal diminishes the resources available for volition and self-control in any other areas). (4) Success or failure of volitional self-control depends to a large extent on a person's level of volitional self-control strength (i.e., people with more self-control strength should be more likely to reach self-control goals than people with less strength); depletions of volitional strength may lead to breakdowns in self-control; and tasks that require high levels of self-control will deplete volitional strength resources more than tasks that require low levels of self-control. (5) The process of volitional self-control (i.e., the exertion of control) expends volitional strength; acts of self-control require the use of self-control strength, and they reduce the amount of strength available for subsequent self-control efforts (i.e., like a muscle, self-control weakens after exertion and requires rest and replenishment before returning to full strength). (6) The decrease in volitional self-control strength is usually temporary (i.e., given time to rest and replenish, it returns to full capacity); however, long-term inability to replenish resources (e.g., chronic stress) might lead to lasting self-control impairment. (7) Significant individual differences in volitional self-control strength likely exist, with some individuals having high levels of volitional strength and others having low levels. (8) Practice (i..e., frequent exercise of self-control) followed by opportunity for rest and full replenishment might lead to an increase in volitional self-control strength capacity over time (i.e., if self-control operates like a muscle, exercising self-control may increase self-control strength in the long-term).

Research on the Strength Model

Muraven, Tice, and Baumeister (1998)

Muraven, Tice, and Baumeister (1998) investigated the ego depletion hypothesis in four studies examining different aspects of self-control: affect regulation and physical stamina, thought suppression and problem-solving task persistence, thought suppression and emotional control, and retrospective accounts of self-control failure. The studies used undergraduate university students enrolled in introductory psychology courses.

The first study tested the hypothesis that affect regulation, trying to control one's emotional reaction, depletes volitional self-control resources and leads to a subsequent decrement on a physical stamina task. Sixty participants were randomly assigned to one of three conditions—*affect suppress*, suppress emotions and facial reactions; *affect amplify*, openly express emotional reactions; and *control*, no affect regulation instructions—and were exposed to a short video featuring distressing content. After the film, all participants filled out mood questionnaires and performed an unrelated physical stamina task. The stamina task required them to hold a closed handgrip tightly for as long as possible. Stamina varied across groups: both affect regulation groups exhibited less stamina compared to the controls. According to the model, affect regulation depleted self-control energy resources and led to a subsequent reduction in stamina (i.e., ego depletion). Self-reported effort and fatigue correlated with ego depletion.

The next study tested the hypothesis that thought suppression depletes self-control resources and leads to decreased persistence on a difficult problem solving task (Muraven et al., 1998). Participants were randomly assigned to one of two groups: *thought suppression,* asked not to think about a white bear; or *no thought suppression,* work on arithmetic problems. Participants then worked on an unrelated task requiring them to try to solve difficult (i.e., unsolvable) anagrams.[7] The thought suppression participants spent significantly less time working on the anagrams than the non-suppression participants. The results supported the strength model and suggested that thought suppression led to ego depletion and reduced persistence on the anagrams. Post-experimental questionnaire responses suggested that students in both groups exerted similar effort levels on tasks and both groups experienced similar moods.

A third study tested the hypothesis that thought suppression depletes self-control resources and leads to difficulties controlling affective expression (Muraven et al., 1998).

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[7]The arithmetic task involved completing multiplication problems (e.g., 345 x 267). Although difficult and requiring effort, arithmetic is not seen as ego depleting because it uses the application of well-learned, *automatic* rules (Muraven et al., 1998).

Participants were randomly assigned to one of two groups—thought suppression (white bear) or no thought suppression (arithmetic)—and were then shown a funny movie. Participants were asked to suppress emotional expression (e.g., no smiling or laughing). Thought suppression participants were observed to have more difficulty suppressing emotions than non-suppression participants. The results supported the hypothesis that thought suppression depleted energy resources and led to a decreased ability to control emotions. There were no group differences in mood or effort.

The final study again tested the hypothesis that self-regulation depletes self-control resources and leads to difficulties in affect regulation (Muraven et al., 1998). Participants were asked to write autobiographical descriptions of times when they succeeded or failed at controlling their emotions (i.e., regulatory success or regulatory failure, respectively). The results were coded by raters and then analyzed through chi-square analyses. Results indicated that participants found self-control to be effortful and factors such as fatigue, alcohol intoxication, stress, and other self-control demands were associated with regulatory failure. Conversely, factors such as having exerted effort and feeling calm were associated with regulatory success.

The studies offered initial support for the strength model of self-control and ego depletion hypothesis. When participants performed two tasks requiring self-control effort, there was a decrement on the subsequent task. The results did not support other hypotheses such as mood or effort effects. Overall, the strongest support was for thought suppression having a negative/depleting effect on subsequent stamina and persistence.

Baumeister, Bratslavsky, Muraven, and Tice (1998)

Four studies by Baumeister, Bratslavsky, Muraven, and Tice (1998) expanded on the research by Muraven et al. (1998) by including measures of *volition* or volitional self-control such as impulse control, choice (e.g., choosing to perform counterattitudinal behaviour), self-regulation, and active responding. The research extended the strength model into the realm of executive functioning.

The first study tested the hypothesis that impulse control depletes volitional self-control resources and leads to subsequently lower frustration tolerance on an unrelated task (Baumeister et al., 1998). Sixty-seven participants were tested individually in a "taste survey" study. The students were hungry, having been asked to skip a meal, and were required to sit in a room that smelled of fresh-baked cookies. Two foods were displayed in front of the students: a plate of chocolate cookies and candies, and a bowl of radishes. Participants were asked to eat from only one of the displays: chocolate cookies/ candies (*low impulse control condition*) or radishes (*high impulse control condition*).[8] Participants were left alone and observed through a two-way mirror. Participants then completed questionnaires on mood and restraint and subsequently completed an unrelated problem-solving task requiring the tracing of geometric figures. Participants were then left alone to work on two impossible-to-solve puzzles. Frustration tolerance was measured by the amount of time spent on the task and the number of attempts made. High-impulse control participants (radishes) had lower time and attempt scores than participants in the other two conditions (low impulse control and no food groups). Post-experimental questionnaire data indicated that the impulse control participants reported higher levels of fatigue. The results supported the ego depletion hypothesis and suggested that resisting temptation led to lower frustration tolerance on a problem solving task.

A second study tested the hypothesis that *choice* (e.g., choosing to perform counter-attitudinal behaviour) depletes volitional self-control resources and then leads to

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[8] A third group of students skipped the impulse control study and only performed the problem solving task (no food condition).

lower frustration tolerance on an unrelated problem solving task (i.e., unsolvable problem solving task used in the previous study) (Baumeister, Bratslavsky et al., 1998). Making a choice is conceptualized as an active and effortful task that requires volitional self-control and presumably depletes volitional self-control resources. The study involved one group of students making a counter-attitudinal speech (e.g., favoring high tuition rates) in high- or low-choice conditions. Another group was allowed to choose to make a pro-attitudinal speech; this also involves making a choice and theoretically could also deplete volitional self-control resources. Thirty-nine college students were tested individually and randomly assigned to one of four conditions: counterattitudinal choice, counterattitudinal no choice, pro-attitudinal choice, and no speech (control). In the counterattitudinal choice condition, students were told that it would be helpful if they made a pro-tuition increase speech. Once the students made their choices, they completed a mood measure and the geometric problem solving tasks used in the previous experiment. As noted above, time and number of attempts were the dependent measures. Time and attempts in the counterattitudinal/ high-choice and pro-attitudinal/high-choice conditions both differed from the counter-attitudinal/no-choice and control conditions: *Individuals in the choice conditions exhibited less persistence.* Consistent with the ego depletion hypothesis, given that *both* conditions involved active choice, the counterattitudinal/high-choice and the pro-attitudinal/high-choice conditions did not differ on time spent and attempts made.

A third study tested the hypothesis that affect regulation, controlling one's emotions, depletes volitional self-control resources and leads to impaired performance on (solvable) anagram solving tasks (Baumeister, Bratslavsky et al., 1998). Anagram solving requires an element of self-control as it requires persistence in trying different letter combinations. Thirty college students were randomly assigned to one of two conditions, *affect suppression* or *no suppression,* and then watched short movies (a comedy sketch or a scene from a tearjerker). Subsequently, the students were asked to perform an unrelated task of solving anagrams. The dependent variable was the number of anagrams solved. Consistent with the ego depletion hypothesis, students in the suppression condition solved fewer anagrams than students in the no suppression condition. The results suggest that ego depletion can lead to impaired performance on solvable tasks.

A fourth study required students to participate in a self-control task and then to participate in a choice task (Baumeister, Bratslavsky et al., 1998). The study tested the hypothesis that self-control depletes volitional self-control resources and then leads one to make passive as opposed to active choices. Eighty-four students were assigned to one of four groups: ego depletion/active quitting, ego depletion/passive quitting, no depletion/ active quitting, and no depletion/passive quitting. The ego depletion condition required participants to perform a difficult letter cancellation task (e.g., cross-out words that contain the letter *e* but that do not contain other vowels) whereas students in the no depletion task completed a simple letter cancellation task (e.g., cross-out all the words containing the letter *e*).[9] Subsequent to the letter cancellation tasks, the students were shown a boring movie (e.g., scene of sterile room). In the active quitting condition, students could stop the movie by pressing a button. In the passive quitting condition, students could end the movie by releasing a button (i.e., pressing the button kept the movie playing). The dependent measure was the amount of time students spent watching the video. On post-experimental questionnaires, students in the ego depletion condition rated themselves as more tired and reported using more concentration. Students in the ego

[9] Participants in the ego depletion condition were first trained on the easy letter cancellation task—creating a prepotent response (cross out every *e*)—before being asked to perform the more difficult task requiring increased self-monitoring and inhibition of the prepotent response (cross out the *e* only if it meets certain criteria).

depletion condition watched more of the movie if quitting required an active response than when quitting required a passive response. In other words, ego depletion appears to make people less likely to make active choices. The results support the idea that active choice requires/uses volitional self-control resources.

The studies by Baumeister et al. (1998) extended the ego depletion hypothesis to the wider realm of volitional self-control. In persistence on problem-solving tasks, time (e.g., time working on a problem) appeared to be a more sensitive measure than attempts (e.g., the number of problem-solving attempts made).

Muraven, Baumeister, and Tice (1999)

Muraven, Baumeister, and Tice (1999) tested the hypothesis that practice in self-control leads to an improvement in self-control and *reduced* ego depletion on a physical stamina task. Participants were randomly assigned to one of three self-control practice conditions—improve posture, regulate mood, or monitor and record eating—or a no-exercise control group. Students in the exercise conditions practiced self-control for two weeks and recorded their results in a diary. Participants performed the white bear thought suppression exercise followed by the handgrip stamina task (see above) prior and post training. All three exercise groups exhibited improved self-control as assessed by a decrease in ego depletion (day 2 minus day 1 scores). The groups that practiced posture monitoring and diet monitoring exhibited the strongest effects. Interestingly, the control group exhibited a *decrease* in self-control. The latter finding stemmed from the fact that students underwent exams around the time of the second experiment session. The authors speculate that these students experienced stress and extraneous self-control demands.

Muraven, Collins, and Nienhaus (2002)

Muraven, Collins, and Nienhaus (2002) extended research on the model into the clinical realm by investigating the effect of ego depletion on alcohol restraint. The main hypotheses were that individuals who engaged in an ego-depleting exercise would drink more alcohol and have higher blood alcohol levels than individuals who engaged in a non-depleting task. Participants were males aged 21 to 35 years randomly assigned to a non-depletion condition (arithmetic) or a depletion condition (thought suppression). Participants then completed an alcohol taste rating test (TRT) in a simulated bar setting. They were presented with two pitchers of beer and asked to rate the beers on taste characteristics (e.g., sweetness). Participants were left alone in the room for 20 minutes, were free to drink as much as they wished, and rated their responses on a computer touch screen. Participants knew that there would be a "driving test" after the TRT and that they could win a prize. There was no driving test; this was a manipulation aimed to encourage participants to restrain alcohol consumption. Consistent with the ego depletion model, thought suppression participants had higher blood alcohol levels and drank more beer than non-depletion participants. The groups did not differ in age, mood, arousal, task enjoyment, task frustration, or trait temptation (i.e., difficulties controlling drinking)—factors that might account for differences in alcohol level and consumption. The effect of trait temptation alone and the interaction between trait temptation and experimental conditions on alcohol consumption were also examined. Trait temptation alone did not affect alcohol consumption, but it did affect consumption in the thought suppression condition. In the thought suppression condition, individuals with high trait temptation consumed more alcohol than those with low trait temptation. That is, the combination of ego depletion and high trait temptation led to greater alcohol consumption.

Schmeichel, Vohs, and Baumeister (2003)

Schmeichel, Vohs, and Baumeister (2003) extended the volitional model by examining the relationship between active self processes, ego depletion, and performance on cognitive tasks. They hypothesized that resource depletion would impair complex thinking processes that require active guidance by the self (e.g., using logic to draw conclusions from ideas, generating novel ideas), but not simpler mental activities that do not require such active guidance (e.g., perceiving, storing, and retrieving information).

The first study tested the hypothesis that ego depletion would impair cognitive performance (Schmeichel et al., 2003). Twenty-six participants were randomly assigned to one of two conditions—*attention regulation*, ignore words flashed on video screen, or *control*, no attention instructions—and were shown a video. Participants then completed a mood scale and then attempted to solve analytical problems. Their performance was measured in three ways: number items correct, number items attempted, and proportion items correct. Consistent with the ego depletion model, attention regulation participants exhibited more poor performance on all three measures than did control participants. They also reported finding the tasks more difficult. Neither mood-related nor fatigue-related effects were found to explain the difference in the two conditions.

A second study tested whether ego depletion would only impair performance on tasks that involved active reasoning and executive control by the self—and not impair performance on simpler tasks (Schmeichel et al., 2003). Thirty-seven participants were randomly assigned to an *emotion regulation condition* (suppress emotional reactions) or control (no regulation). All participants watched a distressing film, completed a mood questionnaire, and completed two cognitive tests: GMAT, a test of basic information processing (e.g., vocabulary, general knowledge); and CET, an open-ended test of fluid cognitive functioning. Consistent with hypotheses, emotion regulation impaired CET scores but not GMAT scores. Ego depletion participants found the tasks as more difficult than control participants. Mood and fatigue did not account for differences in scores.

A third study attempted to replicate findings of the previous studies (Schmeichel et al., 2003). The study used two tasks that demanded different cognitive operations: a reading comprehension task and a nonsense syllable memory task. Task order was counterbalanced. Hypotheses were that the reading comprehension task would use self resources and would be impaired by prior ego depletion and that the nonsense syllable task would not use self resources and would be unaffected by ego depletion. Thirty-six participants were randomly assigned to *attention regulation* (ignore words flashed on video screen) or control (no attention instructions) conditions. After watching a video, participants completed the cognitive tasks in random order. As hypothesized, affect regulation (ego depletion) led to worse performance on reading comprehension, but not nonsense syllable memorization, relative to the control condition. Order did not affect test performance, and there were no mood- or fatigue-related effects.

The studies found that ego depletion impaired performance on higher-order, complex intellectual tasks requiring active self-control and executive functioning and did not impair simple information processing. Interestingly, the handgrip task that was found to be sensitive to ego depletion in previous research can be viewed as a simple cognitive task. The similarity between complex intellectual tasks and the handgrip task is that both require the self to override some response (e.g., muscle fatigue in the handgrip task) and exert a control/executive influence over behaviour; simple tasks do not require such control. Theoretically, ego depletion could affect either simple or complex tasks, provided they require central executive control over which responses would be enacted.

Recent Research

Recent research appears to confirm the volitional self-control strength/ego depletion hypothesis by extending it to other cases where participants exert choice, for example, rating products in a store (Baumeister, Twenge, & Tice, 1998, cited in Baumeister, 2001) and where participants are required to ostracize (i.e., not talk to) another individual (Ciarocco, Sommer, & Baumeister, 2001). Additional research, currently in progress and/or in press, suggests that a *conservation model*—as opposed to a depletion model—may better explain some of the above findings (Baumeister, 2001). According to the conservation model, when people become depleted, they begin to conserve energy—which leads to a decrease in volitional self-control performance—in order to have it available for emergency situations.

Replication Failures

Wieland and Lassiter (2002) and Murtagh and Todd (2004) designed studies to replicate aspects of previous self-control strength research. Both studies failed to find evidence of self-control depletion. Wieland and Lassiter (2002) attempted to replicate the "radishes and chocolates" study (Baumeister et al., 1998). The researchers followed the design of the original study, assigned participants to chocolate, radishes, or no food conditions; and then asked them to work on a geometric figure-tracing task. Contrary to previous results, participants in the chocolate group persisted longer on the task than participants in the depletion radishes group or the no-food control. Results suggested that chocolate motivated participants to persist on the task (i.e., increased self-control resources)—as opposed to ego depletion causing decreased persistence.

In one study, 69 participants were randomly assigned to a depletion or non-depletion condition (Murtagh & Todd, 2004). In the depletion condition, participants did a computerized version of the Stroop Color and Word Test. The task presents participants with differences between printed colour words (e.g., RED) and the colour of the word letters; this creates an interference effect for participants who are asked to name the colour of the letters. In theory, participants enact self-control processes to inhibit reading the words. Non-depletion participants worked on similar computer tasks not requiring the same level of self-control (e.g., report color of a symbol or meaning of a word). As in previous research, participants were measured on handgrip persistence. No differences were found in the handgrip scores of participants in the conditions and there was much variability (i.e., large standard deviations) in handgrip times. Most of the participants were female (in contrast to previous studies), which may suggest gender differences in self-control strength. Finally, demand characteristics influenced performance, as participants seemed motivated to improve handgrip scores in both groups.

Another study by Murtagh and Todd (2004) tried to replicate the thought suppression and anagram study cited previously (Muraven et al., 1998). Seventy-six participants were assigned to one of three conditions: *thought suppression* (do not think about white bear), *thought expression* (think about white bear), or *control* (write down thoughts). Participants wrote down their thoughts for six minutes. They were then given a list of difficult anagrams to solve and were asked to ring a bell when they wished to quit. The dependent measure was the amount of time spent working on the anagrams. Results did not support the hypothesis that individuals in the thought suppression condition would spend less time working on anagrams than other groups. As in the Stroop study, the majority of the participants were female and large standard deviations were observed on the time measures.

Clinical Implications of the Strength Model

As noted, self-control failure is linked to numerous psychosocial and mental health disorders (Dale & Baumeister, 1999). Anxiety and depression, for example, can be viewed as failures to inhibit fearful and negative thoughts, and impulse-control disorders (e.g., addictions, ADHD) can be viewed as failures of behavioural inhibition or lapse-activated self-control failure. Other implications of the model regarding human behavior-change and self-control efforts are (1) that some individuals may have lower levels of self-control strength and (2) that some efforts at self-control may actually exacerbate self-control difficulties. Examples of clinical implications of the strength model include self-awareness and suicide, myopic discounting, and insufficient strength for self-help.

Suicide can be conceptualized as an effort by an individual to escape painful self-awareness (Vohs & Baumeister, 2000). Individuals who are emotionally distressed may engage in behaviours that minimize self-awareness and self-monitoring (e.g., drinking alcohol, engaging in impulsive behaviours). The process of decreasing self-awareness lowers self-control resources and makes it more difficult to inhibit painful thoughts; this may lead to a spiral of increased disinhibitory behaviours and distress—which could culminate in intentional or accidental death.

As noted, self-control and executive functioning often involve behaviours aimed at maximizing long-term over short-term goals. For example, a person wishing to lose weight (long-term goal) may plan to skip dessert (short-term reinforcer). Despite good intentions, people often fail at such self-control efforts when facing a small reinforcer. The term *myopic discounting*—the tendency to prefer a large late reward to a small early one, but then to flip the preference as time passes and both rewards draw nearer—has been applied to describe this phenomenon (Pinker, 1997). In light of the strength model, the person's initial decision—deciding before dinner to skip dessert—could be ego depleting and, therefore, cause subsequent self-control failure.

Treatments for mental health difficulties often require individuals to exert self-control (Dale & Baumeister, 1999; Strayhorn, 2002). For example, cognitive-behavioural treatment for depression asks individuals to monitor thoughts, emotions, and negative situations; challenge negative thoughts and create alternative/positive interpretations; and engage in self-control behaviours (e.g., improve self-care, start exercise). Individuals who are able to do such self-control efforts often show improvement (e.g., more energy, less negative thinking). However, the strength model suggests that some individuals with mental health difficulties (a) may lack the necessary resources to comply with treatment efforts and (b) that their compliance may further deplete their resources and lead to more self-control difficulties. Finally, very small self-control efforts—with high probabilities of success—may slowly lead to increased self-control and overall improvement.

Summary

The self-control strength model suggests that self-control and volition requires energy resources and that the process of exerting self-control/volition temporarily depletes these energy resources. Preliminary research evidence supports this hypothesis. The model has implications for clinical models of mental health disorders and treatment.

Self-control abilities likely follow a normal distribution in the population (Goldstein, 1997). Therefore, some people likely experience more difficulties with self-control and volition than others. For example, individuals with ADHD are hypothesized to have significant difficulties with behavioural inhibition and executive functioning (Barkley, 1997; Dale & Baumeister, 1999; Goldstein, 1997). Key symptoms, constructs, and theories of ADHD are reviewed in the following chapter.

ADHD: A DISORDER OF SELF-CONTROL

Attention-Deficit/Hyperactivity Disorder (ADHD) is the current diagnostic label for individuals who experience difficulties with self-control in hyperactivity, impulsivity, and inattention (APA, 1994; Barkley, 1997; Goldstein, 1997). It is a prevalent childhood mental health disorder and one of the main reasons for which children and adolescents are referred to mental health professionals in North America (Barkley, 1998; Goldstein, 1997). It is estimated that around 2 to 5 percent of children, mostly boys, exhibit behavioural difficulties consistent with ADHD (Barkley, 1997; 1998; Goldstein, 1997, 2000; Paule et al., 2000). If ADHD is viewed in terms of a normal distribution of self-control/behavioural inhibition, it is hypothesized that 15 percent of the population may have significant self-control difficulties (Goldstein, 2002; Paule et al., 2000).

The current edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; APA, 1994) recognizes three main types of ADHD: *Primarily Inattentive type* (ADHD-A), characterized primarily by symptoms of inattention; *Primarily Hyperactive-Impulsive type* (ADHD-HI), characterized primarily by symptoms of hyperactivity and impulsivity; and *Combined type* (ADHD-C), characterized by both inattentive and hyperactive-impulsive symptoms.[10] There is some speculation that inattentive ADHD (i.e., ADHD-A) and hyperactive-impulsive ADHD (i.e., ADHD-HI and ADHD-C) may

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[10] The DSM-IV also uses an ADHD-Not Otherwise Specified (ADHD-NOS) category for individuals who experience significant impairment from ADHD symptoms but who lack the sufficient number of symptoms to achieve a formal diagnosis. Adults with true ADHD diagnosis may sometimes fall into this category because the DSM-IV criteria (and the number of required symptoms) are based on childhood as opposed to adult behaviour. In adults, fewer symptoms may still warrant an ADHD diagnosis.

represent two distinct syndromes: ADHD-A may involve a deficit in processing speed, and ADHD-HI may involve a deficit in behavioural inhibition (with ADHD-C reflecting a more severe form of ADHD-HI; Barkley, 1997; Fisher, 1998).

The following sections briefly review the historical background of the ADHD construct, key symptoms, ADHD in adults and college students, issues related to the assessment of ADHD, and theoretical models of ADHD etiology. The final section highlights the relationship between ADHD and the volitional self-control strength model.

Historical Background

Over the years, diagnostic conceptualizations of ADHD have been negative, viewing it as indicative of "moral character" deficits (e.g., willful disobedience, sloth), brain damage (e.g., minimal brain dysfunction, brain-damaged child syndrome), or poor parenting (e.g., "hyperkinetic reactions"; Barkley, 1997; 1998; Wender, 2000). Moreover, it has been a vague "catch all" diagnosis for children suffering from diverse emotional, behavioural, and neurological disorders (Wender, 1995; 2000). All of the following terms have, at times, been linked to ADHD: "overactivity, inattentiveness and distractibility, impulsivity, affective lability and moodiness, temper outbursts, 'immaturity,' poor peer relations, disobedience, defiance, hostility, 'acting out' or delinquent behaviors, and 'dyslexia' and other 'learning problems'" (Wender, 1995, p. 4).[11]

Historically, there have been numerous literary references to individuals with ADHD-like self-control difficulties (Barkley, 1997). For example, in 1865, German physician Heinrich Hoffman wrote a poem about "Fidgety Phil", a boy who "could not sit still" (cited in Barkley, 1997, p. 4). Serious attention to the disorder began in 1902 when

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[11] The following brief history of ADHD theory and research is based primarily on the work of Barkley (1997, 1998) who has provided extensive and detailed reviews of the ADHD literature.

physician George Still presented data on a sample of children he had seen in his practice (Barkley, 1997; 1998). Still described the children as having "volitional inhibition" and "moral character" defects in inattention, impulsivity, hyperactivity, aggressiveness, lawlessness, and excessive emotionality (Barkley, 1997, p. 4). Still's observations, which hold true today, included (1) that most of the children were boys; (2) they had biological relatives suffering from alcoholism, depression, and criminal conduct; (3) the disorder ran in families (i.e., hereditary); and (4) the disorder was also seen in children who suffered injury to the nervous system.

North American interest in ADHD followed the 1917-1918 encephalitis epidemic after it was observed that children surviving these brain infections often had ADHD-like behavioural self-control difficulties (Barkley, 1997; 1998). These and other cases (e.g., head injury) led to the concept of the "brain-injured child syndrome." Given no evidence of "brain injury" in most of the children, the name evolved in the 1950s into "minimal brain dysfunction" (MBD). Later, as interest focused on specific symptoms (hyperactivity and impulsivity), theories of cortical overstimulation, and more descriptive views of the disorder, the name changed to "hyperactive child syndrome" (Barkley, 1997; 1998).

Due to the influence of psychoanalytic theory, in the 1960s, childhood disorders were viewed as "reactions" to early environmental factors (Barkley, 1997; 1998). As a result, in 1968, the diagnostic term for ADHD became the "hyperkinetic reaction of childhood." The change was important (a) because it emphasized the importance of both inattention/distractibility problems and hyperactivity/restlessness symptoms; and (b) because it stressed that the disorder was benign, that it would diminish by adolescence, and that it was not generally caused by brain damage (Barkley, 1998).

Theory and research in the 1970s and 1980s emphasized the importance of problems with sustained attention, impulse control, and hyperactivity as key facets of the disorder (Barkley, 1997; 1998). The work of Douglas influenced the next diagnostic name change—to "attention deficit disorder" (ADD)—in the DSM-III (APA, 1980). Douglas' theory suggested that ADD comprised major deficits in: "(1) the investment, organization, and maintenance of attention and effort; (2) the ability to inhibit impulsive behavior; (3) the ability to modulate arousal levels to meet situational demands; and (4) an unusually strong inclination to seek immediate reinforcement" (cited in Barkley, 1997, p. 6). The DSM-III changes were important because the disorder was no longer viewed as simply a childhood "behavioral reaction"; there was now emphasis on the cognitive and developmental nature of the disorder, and explicit criteria and symptoms were defined to aid in diagnosis (Barkley, 1997). The DSM-III was also important in that it defined two types of ADD: with and without hyperactivity (ADD+H and ADD-H, respectively).[12] Eventually, due to growing consensus that hyperactivity and impulsivity were central to the disorder, the DSM-III-R (APA, 1987) renamed it "attention-deficit/hyperactivity disorder" (ADHD). Moreover, in the DSM-III-R, ADHD was now classified along with *Oppositional Defiant Disorder* and *Conduct Disorder* under a supraordinate category of *Disruptive Behavior Disorders,* highlighting the fact that the three disorders have substantial overlap and comorbidity (Barkley, 1997; 1998).

Research in 1980s and 1990s challenged the idea that ADHD was primarily a disturbance in attention and suggested that it was a disorder of motivation, insensitivity to response consequences (e.g., intermittent reinforcement), and deficits in rule-governed behaviour (e.g., disobeying rules when faced with situations providing immediate

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[12] According to Barkley (1997), there was no empirical evidence for ADD-H category and it was subsequently dropped in the next revision of the DSM-III (DSM-III-R; APA, 1987).

reinforcement; Barkley, 1997; 1998). Finally, supporting a role for biological factors, research in the 1990s has demonstrated that individuals with ADHD exhibit subtle brain differences (e.g., smaller prefrontal areas, decreased frontal blood flow and glucose metabolism) and deficits on neuropsychological tests sensitive to frontal lobe/executive functioning (Paule et al., 2000; Zametkin et al., 1993; Zametkin et al., 1990).

ADHD in Adults

Consistent with the developmental view of ADHD, many mental health professionals believed (a) that most children and adolescents would "outgrow" the symptoms of ADHD by the time they reached adulthood and (b) that adult ADHD was a rare and unlikely phenomenon (Goldstein, 1997; Murphy & Gordon, 1998). Initial interest in adult ADHD began in the 1970s after the publication of research suggesting that hyperactive/MBD symptoms persisted into adulthood (Mendelson, Johnson, & Stewart, cited in Barkley, 1998) and that childhood hyperactivity was associated with poor adult outcome (e.g., character disorder; Quitkin & Klein, cited in Barkley, 1998).[13] However, it was not until the 1990s that there was some widespread recognition of the disorder in adults (Barkley, 1998; Hallowell & Ratey, 1994; Murphy & Gordon, 1998; G. Weiss & Hechtman, 1993; M. Weiss et al., 1999).

Key Symptoms of ADHD

The key symptoms of ADHD include hyperactivity, impulsivity, and inattention. Related symptoms include difficulty delaying gratification, difficulties with rule-

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[13]The historical and longitudinal research on the symptoms and difficulties experienced by adults previously diagnosed with ADHD as children is controversial, given the changes in nosology and diagnostic criteria over the years. Many children previously diagnosed with MBD or hyperkinetic child syndrome likely suffered from brain injuries and comorbid disorders such as conduct or oppositional disorder (i.e., suffered from mixed syndromes)—and may have not met current ADHD criteria. According to Wender (1995), we do not really know a lot about the prevalence of ADHD symptoms in adults because we do not know enough about the disorder.

governed behaviour, and associated cognitive difficulties. The symptoms and deficits associated with ADHD parallel the self-control difficulties discussed previously.

Hyperactivity and Overarousal

People with ADHD have consistently been described as excessively restless, overactive, easily aroused emotionally, and intolerant of stress (Goldstein, 1997). Hyperactivity may be the best discriminator of persons with ADHD from those with other disorders (Barkley, 1997; Goldstein, 1997). Individuals with ADHD often display difficulties restraining/controlling body movements when they are required to remain in one place for an extended time period. ADHD children tend to be hyperactive, restless, and fidgety. Overt symptoms of hyperactivity tend to diminish in adolescents and adults; nevertheless, many adults continue to report subjective feelings of restlessness. Adults with ADHD tend to fidget and talk excessively (Barkley, 1998). Finally, in addition to hyperactivity, individuals with ADHD often exhibit *overarousal* in that they become emotionally aroused quickly, their emotional reactions are often very extreme and intense, and they exhibit low stress tolerance (e.g., becoming easily frustrated when faced with difficult or effortful tasks; Barkley, 1997; Goldstein, 1997).

Impulsivity

Individuals with ADHD are consistently reported to experience difficulty with impulsivity (Goldstein, 1997): "They appear not to weigh the consequences effectively, nor do these consequences influence their future behavior" (p. 41). Moreover, individuals with ADHD have difficulty with rule-governed behaviour: they *know* what the rules are, what to do or not do, but have difficulty stopping and letting the knowledge control their behaviour (Barkley, 1997, 1998). As a result, others see them as impetuous, unthinking, and unable to learn or benefit from experience, and this pattern of "repeat offending" is viewed as purposeful, non-caring, and oppositional (Goldstein, 1997, p. 41). The failure to respond to aversive consequences in ADHD is consistent with the somatic marker hypothesis (Damsio, 1995) discussed previously and implies frontal lobe involvement (e.g., delayed maturation; Banfield et al., 2004; Barkley, 1997; 2001; Goldstein, 1997; 1999).[14] Failure to "stop and think" may also reflect low self-awareness/self-monitoring and lack of goal-setting (Baumeister & Heatherton, 1996; Baumeister et al., 1994; Carver & Scheier, 1996; 1998). Finally, in terms of the strength model, attempts to comply with rules may reduce self-control behaviour.

Children and adults with ADHD have an apparent need for immediate gratification. They generally do not work well for long-term goals or rewards (Barkley, 1997; Goldstein, 1997). Individuals with ADHD require continuous, immediate, and salient reinforcement in order to sustain effort on tasks (e.g., tasks that are enjoyable; Barkley, 1997). When the reinforcement is intermittent, their behaviour becomes inconsistent and they become more prone to distractibility and impulsive behaviour.

Hyperactivity and impulsivity likely share an underlying mechanism and may fall under the broader construct of *behavioural disinhibition*. Barkley (1997) suggests that behavioural disinhibition represents the key deficit in hyperactive-impulsive ADHD. Behavioural disinhibition involves three main deficits: difficulty inhibiting prepotent responses, difficulty interrupting ongoing responses, and poor interference control. Finally, behavioural disinhibition interferes with executive functioning, the neurological system that facilitates goal-directed behaviour

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[14] Aversive consequences only "kick in" when consequences become imminent (e.g., ADHD individuals who procrastinate only become motivated when a deadline approaches; Goldstein, 1997). The fact that aversive consequences do "kick in" suggests that brain areas such as the VPFC may be immature or under active in ADHD, as opposed to damaged as in the case of frontal lobe lesions.

Inattention

In addition to hyperactivity and impulsivity, individuals with ADHD are often described as inattentive (Barkley, 1997; Goldstein, 1997), and attention complaints are among the most common concerns presented by adults seeking assessment and treatment for ADHD (Murphy & Gordon, 1998). In some cases, apparent inattention may be an artifact of behavioural disinhibition. For example, hyperactive behaviour (e.g., looking around in class) may lead others to perceive that individuals with ADHD are inattentive, even when they are paying adequate attention, and impulsivity may cause ADHD individuals to make "careless" errors that suggest inattentiveness (Goldstein, 2000).

Attention is a multidimensional construct that can refer to alertness, arousal, selectivity, sustained attention, distractibility, attention span, or working memory (Barkley, 1997; Lezak, 1995). Sustained attention or vigilance is usually what people refer to when talking about attention (Lezak, 1995). The inattention experienced by ADHD individuals includes difficulty remaining on task, especially if the tasks are boring, repetitive, difficult, and not of the individuals' choosing (Goldstein, 1997).[15] In particular, they have difficulty with sustained attention or ability to maintain extended effort (Barkley, 1997; Dale & Baumeister, 1999; Goldstein, 1997). These difficulties are consistent with the volitional strength of self-control model reviewed previously.

Inability to invest in the task—as opposed to distractibility and/or the presence of distracters—is the primary problem for individuals with ADHD: "it is less that these individuals are inattentive than that they are *inconsistent* [italics added for emphasis] in applying their attentional skills under certain circumstances" (Goldstein, 1997, p. 40).

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[15] Children and adults with ADHD often have little difficulty paying attention on tasks that they enjoy (e.g., videogames); however, ADHD individuals often make more careless/inattentive errors than non-ADHD individuals on these tasks (Goldstein, 2000).

Moreover, the inattention in ADHD is often task-related: the individual is distracted by irrelevant details in the task itself—as opposed to outside distractions (Barkley, 1997).

Inattention versus Behavioural Disinhibition

As noted previously, there is speculation that inattentive ADHD (i.e., ADHD-A) and hyperactive-impulsive ADHD (i.e., ADHD-HI, ADHD-C) represent two distinct syndromes: Inattentive ADHD may involve a deficit in processing speed (e.g., passivity, mental sluggishness, poor selective attention), and hyperactive ADHD may involve a deficit in behavioural inhibition (e.g., hyperactivity-impulsivity; difficulty stopping, starting, and persisting; Barkley, 1997; Fisher, 1998).[16] Attention deficits in ADHD-A are associated with school difficulties, reading difficulties, and internalizing disorders such as anxiety and depression in adolescence and adulthood (Barkley, 1997; 1998; Fisher, 1998; Slomka, 1998). Conversely, inattention associated with ADHD-HI and ADHD-C is linked to externalizing/disruptive behaviours such as conduct disorder, oppositional defiant disorder, and antisocial behaviour (Barkley, 1997; 1998; Slomka, 1998).

In children with hyperactive ADHD, behavioural disinhibition emerges early in development age (3 to 4) years and prior to development of attention difficulties, which emerge at age 5 to 7 years (Barkley, 1997; Fisher, 1998; Goldstein, 1997). In children with inattentive ADHD, attention difficulties often arise after age 7 years (Barkley, 1997; Fisher, 1998). In hyperactive ADHD, behavioural disinhibition, as measured by DSM-IV criteria, tends to decrease with age, whereas inattention declines at a much slower rate across the life span (Barkley, 1997; Fisher, 1998). The decrease in disinhibition may be

[16] While Barkley and others pose a compelling argument, more evidence is needed, and others pose different models of ADHD (e.g., Brown, 1995a, 1995b; Nigg, 2001; Paule et al., 2000). For example, Brown (1995a, 1995b) argues that inattention and arousal difficulties are central in all forms of ADHD and lead to deficits in self-control, organization, planning, energy, alertness, mood, and memory. The fact that all forms of ADHD respond well to stimulant medication suggests a common underlying mechanism.

somewhat artificial and due to the possibility that DSM-IV criteria are not appropriate for adults or that fewer symptoms may warrant diagnosis of adult ADHD (Barkley, 1997).

Associated Cognitive Impairments

Finally, individuals with ADHD often exhibit difficulties in many other cognitive abilities such as difficulties with motor coordination and sequencing (including slowed visual-motor processing speed), decreased digit span and mental computation (i.e., working memory deficits), poor planning and anticipation, decreased verbal fluency and confrontational communication (e.g., answering questions), poor effort allocation, difficulty applying organizational strategies in tasks, poor internalization of self-directed speech, difficulty adhering to restrictive instructions, poor self-regulation of emotional arousal, and deficits in moral reasoning (Barkley, 1997; Goldstein, 1997; Lovejoy et al., 1999). Overall intellectual functioning is not strongly related to ADHD; however, performance on working memory and controlled motor-processing tasks is often mildly impaired (Barkley, 1997; Goldstein, 1997; Tulsky et al., 1997). The link between these disparate abilities is that most of them fall within the domain of executive functions and they are mediated by the frontal lobes (Barkley, 1997; Lovejoy et al., 1999). Performance in many of these domains may also be affected by volitional self-control strength.

ADHD in Adults

Until about the last 10 years, mental health professionals viewed ADHD as a developmental disorder that is diagnosed almost exclusively in children and adolescents (Goldstein, 1997; M. Weiss et al., 1999). In order to meet DSM-IV criteria, significant symptoms of ADHD need to be present prior to age 7 years (at the latest, before age 12 years; Barkley, 1998). In recent years, there has been a growing consensus that many of the key symptoms of ADHD continue well into adulthood (Goldstein, 1997; M. Weiss et al., 1999) and that nearly 75 percent of adults with childhood ADHD diagnoses continue to experience difficulties related to the disorder (Barkley, 1998; Murphy & Gordon, 1998; G. Weiss & Hechtman, 1993; M. Weiss et al., 1999).

In adults with ADHD, primary symptom complaints tend to involve inattention and subtler forms of hyperactivity-impulsivity such as "mental restlessness" (Goldstein, 1997; Hallowell & Ratey, 1994; M. Weiss et al., 1999; Wender, 2000). Moreover, ADHD adults often have high rates of comorbid disorders such as depression, low self-esteem, anxiety, substance abuse, gambling addiction, and personality disorders (Barkley, 1998; Goldstein, 1997; Hallowell & Ratey, 1994; M. Weiss et al., 1999; Wender, 2000)—many of which also reflect self-control difficulties (Dale & Baumeister, 1999).

ADHD in College Students

Given the current study's focus on ADHD in university and college students, it is important to highlight some research findings in this area. A cross-cultural study of self-reported DSM-IV symptoms in college students from the United States (US), Italy, and New Zealand (NZ) generally supported the two-factor model of ADHD symptoms, but suggested that self-reported symptoms vary across countries (DuPaul et al., 2001). Italian students reported more inattention and disinhibition symptoms than US students, and NZ college students reported more inattention symptoms than US students. Interestingly, male and female subjects reported relatively equal numbers of symptoms. Using DSM-IV criteria, prevalence for ADHD in students ranged from 0 percent (Italian females) to 9 percent (NZ). A recent study in Canada suggested that male and female college students reported similar rates of ADHD symptoms (Konyk, Thomas, & Garinger, 1999). Given that boys outnumber girls in terms of ADHD symptoms, the results may suggest that males with ADHD are less likely to go to college or university.

Studies of psychological functioning of college students with ADHD and ADHD symptoms have found that these students, compared to non-ADHD peers, report lower self-esteem and higher depression (Dooling-Litfin, 1997; Dooling-Litfin & Rosen, 1997; Griffin, 1999; Heiligenstein & Keeling, 1995; Konyk et al., 1999; Presnell, 2000); higher levels of anxiety and obsessive-compulsive behaviours; (Dooling-Litfin, 1997; Dooling-Litfin & Rosen, 1997; Griffin, 1999; Heiligenstein & Keeling, 1995; Konyk et al., 1999), anger, hostility, confrontation, and interpersonal sensitivity (Dooling-Litfin, 1997; Dooling-Litfin & Rosen, 1997; Kern, Rasmussen, Byrd, & Wittschen, 1999; Schouten, 1997); impaired performance on tests of neuropsychological functioning (e.g., working memory, processing speed, executive functioning; Griffin, 1999; Heiligenstein & Keeling, 1995; Turnock, Rosen, & Kaminski, 1998); and lower academic functioning and higher academic underachievement (Heiligenstein & Keeling, 1995; Turnock et al., 1998). Finally, a study comparing students with diagnosed ADHD and those reporting many ADHD symptoms suggests that both groups exhibit similar symptoms and psychological functioning (Richards, Rosen, & Ramirez, 1999). Students in the ADHD-symptom group also disagreed with their parents regarding childhood symptoms (i.e., the parents rated the students as having had lower numbers of ADHD symptoms).

Assessment of ADHD

Assessment of ADHD is complicated by factors such as a lack of consistency in the way ADHD has been diagnosed and in the measures used to assess the disorder. Although many researchers and clinicians advocate a "battery approach," there is no consensus on what should comprise this battery. While some primarily advocate use of questionnaires (e.g., behaviour and symptom checklists) and brief screening measures of intelligence and impulsivity (e.g., Murphy & Gordon, 1998), others advocate the use of comprehensive neuropsychological measures and personality questionnaires (e.g., Culbertson & Krull, 1996; Goldstein, 1997; Lovejoy et al., 1999; Slomka, 1998). The battery approach makes sense for two reasons: (1) if ADHD is a neurological disorder (e.g., associated with delayed maturation and/or dysfunction of the frontal lobes), then adults with ADHD should show some deficits on neuropsychological tests; and (2), given that ADHD individuals often perform inconsistently on neuropsychological tests, a battery approach may better capture this inconsistency (Lovejoy et al., 1999).

Adequate ADHD assessments include evaluations of intellectual, academic, social, and emotional functioning (Culbertson & Krull, 1996; Goldstein, 1997; Murphy & Gordon, 1998). Often, medical examination is also important to rule out infrequent but possible medical causes of ADHD-like symptoms (e.g., adverse medication reactions, thyroid problems). The diagnostic process should also include data from teachers (e.g., school report cards) and other adults who interact with the individual being evaluated.

Difficulties in ADHD Assessment

The assessment of ADHD is difficult, especially in adults, due to a number of general factors: (1) *human nature and nonspecific symptoms* (all of us experience inattention and impulsiveness at times, and neither symptom by itself is pathogenic), (2) *ADHD symptoms and other mental health difficulties* (inattention and poor concentration are associated with numerous DSM-IV disorders), (3) *lack of definite diagnostic markers* (there are no definite biological markers, specific etiological events, or psychological/ neuropsychological test scores that consistently identify ADHD with any degree of certainty), (4) *dimensional nature of ADHD* (ADHD is not an all-or-nothing condition; instead, it represents the extreme end of a continuum or normal curve), (5) *lack of underlying theoretical framework* (until recently, ADHD has been a cluster of symptoms observed in children and adolescents; there has been no underlying theoretical framework by which to guide ADHD research and assessment) (Barkley, 1997; 1998; Goldstein, 1997; 2000; Hallowell & Ratey, 1994; Murphy & Gordon, 1998).

Assessment of ADHD in adults is further complicated for the following additional reasons: (1) *ADHD symptoms change in adulthood* (e.g., physical hyperactivity decreases and is replaced by mental restlessness), (2) *consensus regarding adult ADHD symptoms* (different symptoms and/or fewer symptoms may be sufficient to diagnose ADHD), (3) *comorbid conditions* (assessment of adult ADHD is further complicated by the fact that individuals with ADHD are more likely to suffer from many comorbid difficulties), (4) *late onset disorders* (many mental health disorders have their onset in late adolescence or young adulthood, which further complicates adult assessment), (5) *medical conditions* (adults are more prone to suffer from medical conditions that can produce ADHD-like symptoms), (6) *life stress and trauma* (having lived a longer life, adults are more likely to have experienced stressful or traumatic events), (7) *degree of impairment* (impairment in adults is more difficult to determine as adults work in varied settings and collateral information is unavailable), (8) *informant bias* (media attention has given consumers a great deal of information about the disorder; as a result, they may consciously or unconsciously distort information presented to clinicians), and (9) *retrospective data* (ADHD is a developmental disorder and has primarily been diagnosed in children; in adults, the diagnosis is based on reports of childhood functioning; school records are often not available and information may be distorted) (Barkley, 1997; 1998; Fisher, 1998; Goldstein, 1997; 2000; Hallowell & Ratey, 1994; Murphy & Gordon, 1998; G. Weiss & Hechtman, 1993; M. Weiss et al., 1999).

Etiological and Theoretical Models of ADHD

The precise causes of ADHD are unknown at this time (APA, 1994; Barkley, 1997). The causes that have received the most scientific support are biological in nature and involve brain development and/or brain functioning. Evidence pointing to biological/ neurodevelopmental causes for ADHD includes: the early onset of ADHD symptoms, the persistence of ADHD symptoms over time, the positive response of ADHD symptoms to stimulant medication, ADHD is a worldwide phenomenon, males consistently outnumber females in terms of "hyperactive" ADHD, the heritability of ADHD (i.e., ADHD parents have a high probability of having ADHD children; monozygotic twins exhibit a high concordance for ADHD symptoms), relatives of individuals with ADHD have higher rates of "self-control" psychopathology such as conduct problems and substance abuse (Barkley, 1997; Edelbrock, Rende, Plomin, & Thompson, 1995; Fisher, 1998; Steffensson et al., 1999; van den Oord, Boomsma, & Verhulst, 1994; Wender, 2000).

Much of the biological evidence suggests a general "maturational lag" of the central nervous system and specific lags or deficits in frontal lobe/executive functioning (Barkley, 1997; Steffensson et al., 1999). Other, nonbiological theories focus on the adaptive value of immediate gratification and cultural ADHD.

Delayed Maturation of the Frontal Lobes

Evidence for the involvement of the frontal lobes in ADHD and self-control failure stems from neuropsychological and neuroimaging studies of individuals with ADHD and from studies of individuals with frontal lobe impairment (e.g., frontal lobe lesions). Deficits seen in frontal lobe dysfunction (e.g., in self-control and executive functioning) parallel those observed in ADHD. Several studies have shown that individuals with ADHD often have difficulties on neuropsychological tests that assess frontal/prefrontal functions such as inhibition, persistence, planning, working memory, motor control, and fluency (Barkley, 1997; Denckla, 1996; Fisher, 1998; Lovejoy et al., 1999). Magnetic resonance imaging (MRI) and Position Emission Tomography (PET) studies support the frontal lobe hypothesis (Giedd et al., 1994; Paule et al., 2000; Ratey & Johnson, 1997; Zametkin et al., 1993; Zametkin et al., 1990). Findings for adolescents and adults with ADHD show decreased activation (e.g., reduced blood flow and less glucose metabolism) as well as smaller, less well-developed frontal and prefrontal brain regions (compared to controls). These results suggest structural abnormalities as opposed to brain damage. While neuroimaging studies do not show a causal link between brain morphology and ADHD, they strengthen the argument of a biological cause in ADHD.

Immediate Gratification and Cultural ADHD

Analysis of the results of studies examining various biological factors (e.g., heredity, twin studies), suggests that biological factors explain around 85 percent of the variance in ADHD etiology (Barkley, 1997; 1998; Edelbrock et al., 1995; Steffensson et al., 1999; van den Oord et al., 1994). The remaining variance is accounted for by shared and unshared environmental factors. For example, maternal smoking reflects an environmental insult that can lead to biological process that in turn results in ADHD.

Two interesting theories that highlight environmental factors are Pinker's (1997) theory of the adaptive value of immediate gratification and the ideas of Gleick (1999) and Hallowell and Ratey regarding cultural ADHD (Hallowell & Ratey, 1994; Ratey & Johnson, 1997).

The ability to delay gratification has evolved over time, and most animal species are biologically *programmed* to prefer immediate gratification (Pinker, 1997). For many species, especially those with short life spans, immediate gratification (i.e., get food or sex when it is available) is adaptive and rational (Pinker, 1997).[17] For early humans, who faced hostile environments and dangerous predators, immediate gratification was equally adaptive. The importance of and need for self-control (e.g., delaying gratification) likely evolved or developed over time as humans began to live longer and in larger, mutually dependent societies (i.e., with rules and laws regarding conduct, property, etc.).

A key point in Barkley's (1997) definition of self-control is that individuals need to have developed a "preference" for delayed gratification, which requires both physical (e.g., frontal lobes) and social maturation. ADHD is often associated with poverty and "chaotic" families.[18] For individuals raised in difficult environments, it may be rational and adaptive to be impulsive and to prefer immediate gratification (Pinker, 1997). The point here is not that poverty or growing up in a high-crime environment cause ADHD, but that growing up in certain environments can influence one's preference for immediate gratification and that such a preference may be adaptive in certain environments.

As noted, the diagnosis of ADHD is difficult because symptoms and complaints associated with ADHD are seen in many other disorders and are common in the general population. Most people can relate to complaints of inattention, procrastination, impulsivity, poor frustration tolerance, and feeling "overwhelmed" at times. Some authors (e.g., Gleick, 1999; Hallowell & Ratey, 1994) suggest that ADHD symptoms, such as self-control difficulties, are on the rise, especially in urban North America, and

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[17] Immediate gratification makes sense from a biological/economical perspective (Pinker, 1997). If a person decides to delay gratification and save a dollar for one year, he risks (a) not having the money available sooner if a crisis arises, (b) no guarantee that he will get the money back one year later, and/or (c) the possibility that he might die within the year and never get to enjoy the money.

[18] Given the heritability of symptoms, parents of ADHD children may also have ADHD symptoms, and these symptoms impact on parent-child interactions. Similarly, the higher family rates of depression, alcohol and substance abuse, and criminal or antisocial behaviour may have a similar negative effect on children's development.

that this may be a "side-effect" of North American culture and the rapid progression of the Information Age. Our "fast-paced" culture fosters the development of ADHD-like symptoms and this may explain the higher prevalence of ADHD in North America over Europe (Hallowell & Ratey, 1994).[19] North Americans living in urban areas experience a kind of "pseudo-ADHD" because their world "demands speed and splintering of attention to 'keep up'" (p. 192). As a result, most people can identify with ADHD-like symptoms: being bombarded with stimuli, being distracted, having too many obligations and not enough time to meet them, being in a chronic hurry, being late, becoming easily frustrated, finding it difficult to slow down and relax, and craving high stimulation when it is withdrawn (p. 192). As everything becomes "faster" (e.g., faster computers, faster access to news and information, faster music, etc.), more people begin to complain of feeling overextended and "behind" (Gleick, 1999).

ADHD and the Strength Model of Volitional Self-Control

As noted previously, the volitional self-control strength model proposed by Baumeister, Muraven, and colleagues has many implications for clinical theory and research. These implications include the hypotheses that lack of self-control strength underlies many forms of mental illness and that self-control efforts may at times lead to decreased self-control and exacerbated psychological difficulties. Another implication is that individuals in the population vary in self-control strength, with some having low levels and higher risk for self-control difficulties. A testable hypothesis for the model is whether individuals with self-control difficulties exhibit more ego depletion compared to individuals with "normal" self-control strength. Individuals with ADHD symptoms

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[19] The fact that Europe uses more strict diagnostic guidelines for ADHD diagnosis is likely the main factor in why ADHD prevalence rates vary between the two continents (Barkley, 1997; Maté, 1999).

represent a population characterized by self-control difficulties. To date, no research has examined the relationship between the strength model of self-control and ADHD. Barkley's (1997) behavioural disinhibition/executive functioning model of ADHD is consistent with the volitional strength of self-control model (Dale & Baumeister, 1999). Key components of the strength model, such as self-monitoring and control of attention (i.e., being able to direct one's attention onto a task; Baumeister et al., 1994), have an obvious connection to the attention deficits observed in ADHD. Moreover, the ongoing needs for self-control—and the reminders and reprimands by others to pay attention, stay focused, and sit still—may play a role in ego depletion. According to the self-control strength model, the self-control efforts exerted by individuals with ADHD may deplete their energy resources and exacerbate their self-control difficulties.

Recent research on the strength model indicates conceptual overlap between self-control, volition, and other executive-functioning-type tasks (Baumeister, 2000; 2001; Baumeister et al., 1998; Muraven & Baumeister, 2000). Executive functioning might be conceptualized in terms of the strength model. The implication is that performing successive executive functioning tasks, given their novelty requirements for inhibition and higher-order information processing, would impair performance on subsequent executive and self-control tasks (e.g., Schmeichel et al., 2003). Given that individuals with ADHD symptoms often exhibit difficulties in executive functioning tasks, it can be hypothesized, in terms of the volitional strength model, that these tasks should be particularly ego depleting for this population.

OVERALL SUMMARY AND STATEMENT OF PROBLEM

The term *self-control* refers to an array of constructs such as delay of gratification, impulse control, persistence, and affect regulation—all of which are crucial to attaining personal goals. Self-control is a key human ability and is associated with academic, vocational, and financial success; physical health; and overall well-being. Conversely, poor self-control is linked to diverse psychosocial difficulties such as underachievement, crime, addictions, and mental illness.

Self-control can be conceptualized as both a strength (i.e., willpower) and as the efforts one exerts in order to meet one's goals (e.g., forcing oneself to persist at a difficult task). Recent research by Baumeister, Muraven, and colleagues (e.g., Baumeister et al., 1998; Muraven et al., 1998) suggests that self-control resembles muscle functioning in that (a) self-control requires energy, (b) exercising self-control temporarily depletes this energy (i.e., muscle fatigue), and (c) the energy depletion—termed *ego depletion*—leads to subsequent difficulty in self-control. For example, engaging in impulse control on one task may lead to decreased persistence on a subsequent physical stamina task. Research on the strength model suggests that it extends to other volitional/executive functioning types of tasks such as decision-making and problem solving.

To date, research on the volitional self-control strength model has focused primarily on normal participants (e.g., undergraduate university students). The goal of the current study was to extend the research into the clinical realm by including a population that is characterized as having difficulties with self-control and executive functioning.

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder of self-control, characterized by difficulties with behavioural inhibition (i.e., hyperactivity-impulsivity), attention control, and executive functioning.

The goals of the study were to replicate previous self-control strength research and to extend the research by incorporating additional measures of self-control and executive functioning (e.g., a neuropsychological problem solving task) and, more importantly, by including individuals with clinically-defined difficulties of self-control (i.e., individual with symptoms of ADHD). Based on previous self-control strength research, it was expected that individuals with ADHD symptoms would exhibit greater levels of ego depletion than individuals without ADHD.

ADHD participants were selected on the basis of self-reported ADHD symptoms on two retrospective childhood questionnaires, the *Attention Behavior Checklist for Children* (ABC-C; Barkley & Murphy, 1998; Goldstein, 1997; Murphy & Barkley, 1995), a self-report DSM-IV checklist used in research and clinical practice; and the *Wender Utah Rating Scale* (WURS; Ward, Wender, & Reimherr, 1993), a commonly used self-report checklist of retrospective ADHD symptoms. In addition, ADHD symptom participants were required to report ongoing difficulties academic and interpersonal difficulties consistent with ADHD in a clinical interview and on background questionnaires, including the *Attention Behavior Checklist for Adults* (ABC-A; Barkley & Murphy, 1998; Goldstein, 1997; Murphy & Barkley, 1995), a self-report DSM-IV checklist of adult ADHD symptoms. The ADHD participants were matched with peers in terms of age, gender, and educational faculty (e.g., Arts), and both groups were randomly assigned to a Depletion or Non-Depletion condition.

The Conners' *Continuous Performance Test* (CPT; Conners, 1994), a computer-administered test that requires inhibition and focused attention, served as the depletion task in the study. The control/non-depletion task consisted of arithmetic questions used in previous self-control research (e.g., Muraven et al., 1998).

Key dependent measures, hypothesized to be sensitive to ego depletion, included a physical handgrip stamina task used in previous self-control research (e.g., Muraven et al., 1998) and the Gambling Task (Bechara et al., 1994; Bechara et al., 1997; Damasio, 1995), a computer-administered task of frontal lobe/executive functioning. Net decreases in physical stamina on the handgrip task (i.e., negative stamina change scores) and failure to inhibit disadvantageous responses on the Gambling Task (i.e., positive response change scores) were conceptualized to indicate ego depletion. Detailed hypotheses are presented in the next section. Participants also completed the *Vocabulary* subtest of the *Wechsler Adult Intelligence Scale—Third Edition* (WAIS-III; Wechsler, 1997). Based on previous research (e.g., Schmeichel et al., 2003), it was hypothesized that performance this task would be relatively immune to ego depletion.

HYPOTHESES

Hypothesis 1: Depletion Protocol Effect

Hypothesis 1 predicted an overall Protocol main effect: Participants in the Depletion protocol (Conners' Continuous Performance Test; CPT) would exhibit poorer performance on volitional self-control tasks (i.e., more self-control strength or ego depletion) than participants in the Non-Depletion protocol (Arithmetic; AR). Specifically, CPT Depletion participants would exhibit (1) less persistence and physical stamina (i.e., lower net time scores on the Handgrip task) and (2) poorer impulse control and decision-making (i.e., failure to inhibit and decrease disadvantageous responding on the Gambling Task) than AR Non-Depletion participants. It was also hypothesized that performance on a test of verbal intellectual functioning (i.e., vocabulary or crystallized verbal intelligence) would be immune to protocol depletion effects.

Hypothesis 2: ADHD Group Effect

Hypothesis 2 predicted an overall Group main effect: Participants with self-reported ADHD symptoms (ADHD group) would perform poorer on volitional self-control tasks than participants without ADHD symptoms (Non-ADHD group). Specifically, ADHD participants would exhibit (1) less persistence and physical stamina (i.e., lower net time scores on the Handgrip task) and (2) poorer impulse control and decision-making (i.e., failure to inhibit and decrease disadvantageous responding on the Gambling Task) than Non-ADHD participants. It was also hypothesized that performance on a test of verbal intellectual functioning (i.e., vocabulary or crystallized verbal intelligence) would be immune to group effects (i.e., similar performance between ADHD and Non-ADHD participants).

Hypothesis 3: Protocol X Group Effects

Hypothesis 3 predicted a significant interaction effect between Protocol (CPT or AR) and Group (ADHD or Non-ADHD): ADHD participants in the CPT Depletion protocol (ADHD/CPT participants; theoretically, the most-depleted group) would exhibit the poorest performance on volitional self-control measures. Specifically, ADHD/CPT participants would exhibit (1) less persistence and physical stamina (i.e., lower net time scores on the Handgrip task) and (2) poorer impulse control and decision-making (i.e., failure to inhibit and decrease disadvantageous responding on the Gambling Task) than other participants. It was not expected that ADHD/CPT participants would differ significantly from other participants in word definition skills (i.e., vocabulary or crystallized verbal intellectual functioning).

Conversely, it was hypothesized that Non-ADHD participants in the AR Non-Depletion (Non-ADHD/AR participants; the least-depleted group) would exhibit the best performance on the above volitional self-control measures. Again, it was not expected that Non-ADHD/AR participants would differ significantly from other participants in word definition skills (i.e., vocabulary or crystallized verbal intellectual functioning).

Manipulation Effects

Depletion Protocol Effects

It was hypothesized that CPT Depletion participants would report higher levels of fatigue and perceived task difficulty than AR Non-Depletion participants. It was also hypothesized that participants' mood, levels of arousal, and motivation/effort put into tasks would be similar across the depletion and non-depletion protocols.

ADHD Group Effects

It was hypothesized that ADHD participants would report higher levels of fatigue, perceived task difficulty, negative mood, and arousal than Non-ADHD participants.

Protocol X Group Effects

It was hypothesized that ADHD/CPT participants—the most-depleted group—would report higher levels of fatigue and perceived task difficulty than other participant groups. Conversely, Non-ADHD/AR participants—the least-depleted group—would report lower levels of fatigue and perceived task difficulty than other participant groups.

METHOD

Participants

Participants were 108 students enrolled at the University of Manitoba (UM), the University of Winnipeg, or Red River College, all of which are located in Winnipeg, Manitoba, Canada. Fifty-four of the participants reported having had significant childhood and ongoing adult symptoms consistent with ADHD (ADHD group), and 54 participants were peers matched in age, gender, and educational faculty (e.g., Arts, Science, etc.; Non-ADHD group). Similar matching criteria have been used in other studies comparing adults with and without ADHD (e.g., Barkley, Murphy, & Kwasnik, 1996). Selection criteria and detailed group comparisons are provided later in this section.

Number of participants was based on effect size and power in previous studies (e.g., Baumeister, Bratslavsky et al., 1998; Muraven et al., 1998). ADHD and Non-ADHD participants were randomly assigned to one of two experimental conditions: *Arithmetic Non-Depletion* (AR Non-Depletion), requiring the completion of arithmetic problems, or *Conners' Continuous Performance Test Depletion* (CPT Depletion), requiring performance of a computerized self-control task. Random assignment was achieved through use of random number tables.

The AR Non-Depletion and CPT Depletion groups were equivalent in age (overall $M = 24.72$, $SD = 6.07$), gender (approximately 50% male and female), ethnicity (approximately 66.7% White/Caucasian), and education ($M = 14.47$, $SD = 2.38$). Most (81.5%) were single. Almost half of the participants (48.15%) were in their first or second year of university (i.e., University 1 [U1]) and had not yet declared or decided upon a major or faculty. After U1, Arts, Science, and Business/Commerce were the most frequently endorsed faculties. Ninety-five percent of the participants were attending the University of Manitoba. Detailed information about the participants and comparisons between ADHD and Non-ADHD participants are presented in the Results section and in Appendix A.

ADHD Symptom Group Selection Criteria

Measures used to select participants for the ADHD symptom group included the *Attention Behavior Checklist for Children* (ABC-C; Barkley & Murphy, 1998; Goldstein, 1997; Murphy & Barkley, 1995), a self-report DSM-IV checklist used in research and clinical practice; the *Wender Utah Rating Scale* (WURS; Ward et al., 1993), a commonly used self-report checklist of retrospective ADHD symptoms; the *Attention Behavior Checklist for Adults* (ABC-A; Barkley & Murphy, 1998; Goldstein, 1997; Murphy & Barkley, 1995), a self-report DSM-IV checklist; and responses to background interview questions suggesting ongoing academic and interpersonal difficulties consistent with ADHD (e.g., poor attention, poor organization). The minimum requirements for inclusion were (1) six childhood symptoms on the ABC-C (i.e., total number of items scored as 2 or 3 on the scale; see next section) *or* a score of 35 or more on the WURS and (2) four ongoing adult symptoms on the ABC-A *or* self-report of ongoing difficulties consistent with ADHD on the background interview questions. Exclusion criteria were limited to neuropsychological factors (e.g., head injury, seizure disorder) that could confound results. The resulting ADHD participant group included individuals with inattentive, hyperactive-impulsive, combined, and subclinical (ADHD-NOS) subtypes. It could be argued that only participants with ADHD hyperactive-impulsive symptoms should have been included in the current study because these symptoms are most consistent with Barkley's (1997) behavioural disinhibition model of self-control and because primarily inattentive symptoms may represent another mechanism or disorder (Barkley, 1997; Fisher, 1998). Although compelling, the two-disorder model remains to be verified. Moreover, it can be argued that both inattentive and hyperactive-impulsive subtypes are disorders of self-control that have overlapping difficulties and similar presentations in adults (e.g., mental restlessness and inattention; Goldstein, 1997; Hallowell & Ratey, 1994). Furthermore, the DSM-IV (APA, 1994) identifies both subtypes as belonging to one diagnostic category, and other researchers have hypothesized competing ADHD models that place inattention/poor control over attention as the central deficit in all ADHD subtypes (e.g., Brown, 1995a, 1995b; Nigg, 2001; Paule et al., 2000).

The rationale for using relatively broad selection criteria was also influenced by the following: (1) *Research goals and exploratory nature of the study.* The goals of the study were to replicate past research on ego depletion, expand the research by including new protocols and measures, and extend the research into the clinical realm by including participants with self-control difficulties (i.e., ADHD symptoms). Given these goals, the study was viewed as exploratory in nature. (2) *The dimensional nature of ADHD and the prevalence of ADHD in university and college.* ADHD is viewed as a dimensional disorder existing on the "low end" of the self-control continuum. The prevalence of ADHD in the general population is low, around 3 percent (Goldstein, 1997). It is often a debilitating disorder linked to numerous academic and interpersonal difficulties. Given the low prevalence and the high risk of associated difficulties, the likelihood of individuals with severe ADHD completing high school and then attending university or college is low. Conversely, individuals with moderate/fewer symptoms (i.e., subclinical

ADHD) may be more likely than those with full ADHD to finish high school and continue onto post-secondary education. Therefore, in a post-secondary setting, there is a greater likelihood of finding individuals who have some ADHD symptoms as opposed to full diagnoses. Subclinical ADHD is associated with significant self-control difficulties and warrants further research in college populations (Richards et al., 1999). (3) *Difficulties in ADHD assessment.* As noted, ADHD is difficult to assess, especially in adults. Given the large number of participants required in the current study and the aforementioned concerns regarding prevalence, formal psychological assessment of all participants was outside the scope of the current study. The use of cut-off scores on standardized self-report measures met an adequate research standard for the current study (Konyk et al., 1999). (4) *Difficulties in recruitment.* An additional rationale emerged from the data collection process. ADHD participants often arrived late or missed appointments. Although arriving late may be diagnostic of ADHD (Hallowell & Ratey, 1994), it hinders the research process. Broadening the participant pool offers a partial remedy.

Non-ADHD Group Selection Criteria

Non-ADHD participants matched ADHD participants in terms of gender, age (plus/minus 1 year), and educational faculty (e.g., Arts, Science). Exclusion criteria for Non-ADHD participants were scores of 6 or greater on the ABC-C, scores of 35 or more on the WURS, and significant complaints of self-control difficulties or ADHD symptoms in adulthood. Participants were also excluded if they reported a history of head injury or other potentially confounding neuropsychological difficulties (e.g., seizure disorder).

Measures

Background Measures and Questionnaires

Background Questionnaire

Participants completed a brief background questionnaire developed by the primary investigator and based on standardized questionnaires and interviews for adult ADHD assessment (e.g., Barkley & Murphy, 1998) and general adult assessment and research. The questionnaire inquired about demographic data (e.g., age, gender, education, marital status, occupation), school history (e.g., grades, best and worst subjects), medical history (e.g., history of head trauma) and current stressors (see Appendix B for examples of background questionnaire items).

Attention Behavior Checklists for Children and Adults

The *Attention Behavior Checklist for Children* and the *Attention Behavior Checklist for Adults* (ABC-C and ABC-A, respectively; Barkley & Murphy, 1998; Goldstein, 1997; Murphy & Barkley, 1995) parallel the DSM-IV diagnostic criteria for ADHD. The checklists include 18 symptoms scored on a 4-point Likert scale (0 = "never or rarely," 1 = "sometimes," 2 = "often," and 3 = "very often") with items scored 2 or 3 being indicative of symptom endorsement. Scores on both the ABC-C and ABC-A range from 0 to 54. Both tests generate three factors (inattentive, hyperactive-impulsive, and combined) consistent with DSM-IV criteria for ADHD. For adults in the 17 to 29 year age range, mean scores for inattention, hyperactivity-impulsivity, and combined/total score are 6.3, 8.4, and 14.7, respectively (Murphy & Barkley, 1995). Number of symptoms endorsed (i.e., scores of 2 or 3 only) for the same scales are 1.2, 2.0, and 3.2, respectively (Murphy & Barkley, 1995).

Weiss and colleagues (1999) recommend that clinicians use the ABC-A scale as the basic tool for assessment of ADHD symptoms in adults because: (1) it is consistent with childhood criteria, (2) it is consistent with the DSM-IV diagnostic scheme and has been used to publish normative data, (3) it is written in a language appropriate for adolescents and adults, and (4) it allows for both categorical and dimensional ratings. However, they caution that "responses to questions from the *DSM-IV* are *only as valid as the patient's adequacy in understanding the nature of the questions,* [italics in original] and whether individuals have "an intuitive sense of the population norms one would need to understand to determine whether any given task is relatively more difficult for him or her"(p. 53). The authors suggest that individuals may underreport ADHD symptoms on the ABC-A and that childhood ADHD criteria may under diagnose ADHD in adults.

Wender Utah Rating Scale

The *Wender Utah Rating Scale* (WURS; Ward et al., 1993) is a retrospective self-report measure of ADHD symptoms in childhood and has been employed by a number of researchers. The WURS consists of 61 items scored on a 5-point Likert scale (0 = "not at all," 1 = "mildly," 2 = "moderately," 3 = "quite a bit," and 4 = "very much"); 25 items contribute to a retrospective ADHD symptom score. A score of 46 or above is indicative of adult ADHD. However, in research, lower cutoff scores may be used (e.g., 35; Konyk et al., 1999). The WURS exhibits adequate to good reliability (Rossini & O'Connor, 1995; Ward et al., 1993) and validity (Weyandt, Linterman, & Rice, 1995; Weyandt, Rice, Linterman, Mitzlaff, & Emert, 1998); however, the scale appears to correlate with negative mood and anxiety (John, 2000; Konyk et al., 1999; Mancini, Van-Ameringen, Oakman, & Figueiredo, 1999).

Several studies have examined reliability and validity of the WURS in college students (e.g., John, 2000; Richards et al., 1999; Rossini & O'Connor, 1995). John (2000) found that WURS scores in college students decreased over time and were associated with mood (i.e., higher ADHD symptoms were associated with negative mood). Rossini and O'Connor (1995) investigated the internal consistency, temporal consistency, and temporal stability of the WURS on a sample of college students reporting current ADHD symptoms and found good reliability over a 4-week period.

Center for Epidemiological Studies—Depression Scale

The *Center for Epidemiological Studies—Depression Scale* (CES-D; Radloff, 1977) is a brief 20-item scale focusing specifically on the experience of depression and is designed for use in both clinical and general populations. It assesses depressed mood; feelings of guilt, worthlessness, helplessness, and hopelessness; psychomotor retardation; loss of appetite; and sleep disturbance. Participants indicate how many times they have experienced each of the 20 symptoms "over the past week" on a 5-point Likert-type scale (0 = "rarely or none of the time [less than one day]," 1 = "some or a little of the time [1-2 days]," 3 = "occasionally or a moderate amount of the time [3-4 days]," 4 = "most or all of the time [5-7 days]"). Scores on the CES-D range from 0 to 60, with higher scores indicating more depression. A score of 16 or higher has been established as indicating possible depression (McDowell & Newell, 1996).

Coefficient alphas for the CES-D range between .85 for the general population to .90 for psychiatric samples (Corcoran & Fischer, 1987; McDowell & Newell, 1996). Test-retest reliability of the CES-D with three month to one year test-retest intervals range between .32 to .54. This relatively low reliability is expected as depression ratings vary considerably over such as long time interval.[20]

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[20] The purpose of including the CES-D in the current study was to use it as a screening measure to exclude participants with significantly high depression symptoms. The screening approach was abandoned upon finding that the CES-D correlated highly

Self-Control Scale

The *Self-Control Scale* (SCS; Tangney et al., 2004) is a 36-item self-report trait measure of self-control. Examples of SCS items include "I am lazy" and "I have a hard time breaking bad habits." SCS items are scored on a 5-point Likert type scale (1 = "not at all" to 5 = "very much") and are summed to produce a total self-control score. Scores on the SCS range from 36 to 180, with higher scores reflecting more difficulty with self-regulation. The SCS is based on an extensive review of published studies on self-control processes and failures and has been employed in two large studies of undergraduate university students (Tangney et al., 2004). Internal consistency reliability estimates are high (alphas ranging from .83 to .89) as is test-retest reliability (alpha = .89). Controlling for desirable responding, preliminary results indicate that SCS scores correlate with numerous indicators of good psychological functioning: better academic performance, fewer problems regulating eating, decreased problem drinking, better psychological adjustment, less psychopathology, higher conscientiousness, greater emotional stability, more agreeableness, secure attachment style and a positive environment in the family of origin, empathic perspective taking, decreased anger management difficulties, and a more adaptive moral emotional style (e.g., "shame-free" guilt).

Protocol Instruments

Conners' Continuous Performance Test

The Conners' *Continuous Performance Test* (CPT; Conners, 1994) is a computer-administered test of attention and concentration. The test is administered on an IBM

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with measures of ADHD and self-control difficulty. Almost all of the ADHD symptom participants reported high numbers of depression symptoms (see Appendix A for details). As a result, depression was not used an exclusion criteria. Results of the study were analyzed with and without depression as a covariate (e.g., ANCOVA). No significant effect of depression on the main effects was observed.

compatible desktop computer. It presents 360 letters (approximately 1 inch in size) on the computer screen one at a time for approximately 250 milliseconds. The interstimulus interval (ISI) varies throughout the test (e.g., 1, 2, or 4 seconds).[21] Participants are required to depress the spacebar when any letter except the letter "X" appears on the screen. Ninety percent of the letters are other than "X" and this event rate is consistent across the task. The CPT takes approximately 14 minutes to complete. Standard protocol for the CPT is that it be administered individually in an environment free of distractions, with the examiner present, and with a brief practice at the start of the test. The CPT generates multiple dependent measures. CPT measures sensitive to differences between individuals with and without ADHD include number of *commission errors* (scored if the participant presses the spacebar when the letter "X" appears; suggestive of impulsive responding or disinhibition), number of *omission errors* (scored if the participant fails to press the spacebar when a letter other than "X" appears; suggestive of inattention), and overall impairment (i.e., an overall index linked primarily to variability and inconsistent performance, arousal, and attention across the task ISIs and ISI blocks) (Barkley et al., 1996; Conners, 2004; Epstein, Conners, Sitarenios, & Erhardt, 1998).

The current study used the CPT as an ego depletion task. The task requires ongoing inhibition of a behavioural response (i.e., not pressing the spacebar to a target stimulus), the CPT was conceptualized as potentially being an ego-depleting task. Results of pilot testing confirmed that the completion of the CPT resulted in ego depletion (see "Design and Procedure" section below).

Arithmetic Questions

The arithmetic test used in the Arithmetic (AR) Non-Depletion protocol consisted

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[21] The three ISIs are presented in various combinations across six blocks over the course of the test. Each block consists of a different sequence combination of the ISIs.

of 42 multiplication problems (e.g., 367 x 598) arranged on an 8½ by 11 inch sheet of paper. The questions and format were the same as used in previous self-control strength research (e.g., Muraven et al., 1998; 1999). As noted previously, solving arithmetic questions is hypothesized to require a low amount of self-control resource. Solving arithmetic questions requires the systematic application of well-learned rules.

Dependent Measures

Handgrip Task

The handgrip task used in previous self-control research provides a measure of persistence and physical exertion (Baumeister, Bratslavsky et al., 1998; Muraven et al., 1998; 1999). Physical exertion (in athletes, soldiers, etc.) requires self-control to make oneself continue to work despite physical discomfort and fatigue (Muraven et al., 1998, p. 777). The task assesses physical stamina, measuring how long (sec) a participant can continuously squeeze a handgrip. Squeezing handgrips requires considerable effort, and maintaining grip is almost purely a measure of self-control unrelated to overall body or grip strength (Rethlingshafer, 1942, & Thornton, 1939, cited in Muraven et al., 1998). Because handgrip task performance varies as a function of hand strength, performance is measured twice, before and after the depletion manipulation (Trial 1 and Trial 2, respectively). The difference score (*HG-Net*), obtained from subtracting Trial 1 performance (sec) from Trial 2 performance (sec), provides a measure of self-control resource or ego depletion. Larger negative scores suggest greater amounts of depletion.

In the task, a piece of paper is inserted into the handgrip when the participant begins to squeeze (Baumeister, Leith, Muraven, & Bratslavsky, 1998; Muraven et al., 1999; Muraven et al., 1998). The paper is held in place by the handgrip and falls the moment that the participant begins to relax his or her grip. Timing begins at the moment the paper is inserted and stops at the moment that the paper falls. This procedure controls for the fact that individuals may release the handgrip in different ways—such as a gradual release (which might not be perceived by the examiner) versus a quick release. In this method, the paper falls as soon as the participant begins to release.[22]

Brief Mood Introspection Scale

The *Brief Mood Introspection Scale* (BMIS; Mayer & Gaschke, 1988) is a 16-item mood adjective scale assessing 8 mood states: (1) *happy* (happy, lively), (2) *loving* (loving, caring), (3) *calm* (calm, content), (4) *energetic* (active, peppy), (5) *fearful/ anxious* (jittery, nervous), (6) *angry* (grouchy, fed up), (7) *tired* (tired, drowsy), and (8) *sad* (gloomy, sad). Participants rate each adjective on a 7-point Likert-type scale (1 = "definitely do not feel", 3 = "do not feel", 5 = "slightly feel", and 7 = "definitely feel") in terms of their present mood (i.e., "Circle the response on the scale below that indicates how well each adjective or phrase describes your present mood"). The BMIS items form two independent scales: *Pleasant-Unpleasant* (BMIS-PU) and *Aroused-Calm* (BMIS-AC). BMIS-PU assesses current mood (pleasant vs. unpleasant) and consists of a sum of the "pleasant" adjectives (active, clam, caring, content, happy, lively, loving, and peppy) plus the reverse-coded sum of the "negative" adjectives (drowsy, tired, fed up, gloomy, grouchy, jittery, nervous, and sad). BMIS-AC assesses current arousal (aroused vs. calm) and consists of a sum of the "aroused" adjectives (active, fed up, gloomy, jittery, lively, loving, nervous, and peppy) plus the sum of the reverse-coded "calm" adjectives (calm, tired). The BMIS scales have good factorial validity and item reliability. They correlate strongly with their pure factor scales (r = 0.93 to 1.00), and their Cronbach's alpha

[22] Instructions regarding the Handgrip task protocol were provided by Mark Muraven (personal communication, March 3, 2003). Participants used their self-reported non-dominant hand on the task.

reliabilities range from $r = 0.76$ to 0.83 (Mayer & Gaschke, 1988, p. 104). These short scales quickly and easily assess changing mood states. The BMIS has been used in previous self-control/ego depletion research (e.g., Muraven et al., 1998) as a manipulation check variable.

Gambling Task

Developed by Bechara, Damasio, and colleagues (Bechara et al., 1994; Bechara, et al., 1997; Damasio, 1995), the computerized *Gambling Task* (GT) is a laboratory instrument believed to be sensitive to the decision-making and impulsiveness impairments seen in patients with frontal lobe damage. The GT has been used in research on Damasio's (1998a; 1998b) somatic marker hypothesis. The task uses four decks of cards: A, B, C, and D. Participants' goal is to maximize profit on a loan of play money. Participants are required to make a series of 100 card selections. However, they are not told ahead of time how many card selections they must make. Participants can select one card at a time from any deck they choose, and they are free to switch from one deck to any other deck at any time, and as often as they wish. Participants' decisions to switch from one deck to another are influenced by various schedules of immediate reinforcement and punishment. Each card selection wins a sum of money; however, some card selections also punish/lose money. On one card selection the participant wins \$100; on the next card selection, the participant wins \$200, but also loses \$175, for a net win of \$25. The win/loss schedules are preprogrammed and known to the examiner, but not to participants, and entail the following: Every time participants select a card from decks A or B, they win a large sum of money (e.g., \$100.00); every time they select a card from decks C or D, they win a smaller amount (e.g., \$50.00). In each of the four decks, they face unpredictable punishments (i.e., money loss). The punishment is higher in the high-paying decks (A and B) and lower in the low-paying decks (C and D). For example, if ten cards were picked from deck A, one would earn $1,000. However, in those ten picks, one would encounter five unpredictable punishments, ranging from $150 to $350, resulting in a total cost of $1,250. Deck B is similar: ten cards picked from deck B would earn $1,000; however, after ten picks would encounter one high punishment of $1,250. Conversely, every ten cards from deck C or D earn only $500, but cost only $250 in punishment. Hence, decks A and B are *disadvantageous* because they cost more in the long run (net loss of $250.00 every ten cards), and decks C and D are *advantageous* because they result in an overall gain in the long run (net win of $250).

The outcome measure of GT performance used in the current study was *GT-AB*, a frequency change score of disadvantageous cards (decks A and B) chosen at the end of the task compared to the start of the task (i.e., number of cards chosen from A and B in trials 76 to 100 minus number of cards chosen from A and B in trials 1 to 25). Negative GT-AB scores suggest better performance or *decreased disadvantageous responding*, scores of zero indicate no change in disadvantageous responding, and scores greater than zero suggest *increased disadvantageous responding*. In the current study, GT-AB scores were calculated using by a computer program that I wrote in Perl (see Appendix C).

Research on the Gambling Task. The GT is a research tool and not a standardized assessment instrument. Nevertheless, the task shows promise in identifying individuals with difficulties with decision-making and impulsivity. Decreased performance (i.e., disadvantageous decision making), compared to controls, has been found in individuals with frontal lobe dysfunction (Bechara et al., 1994; Bechara et al., 1997), patients with Huntington's Disease (Stout, Rodawalt, & Siemers, 2001), patients with spinal cord injuries (North & O'Carroll, 2001), and substance abusers (Fishbein, 2000; Monterosso, Ehrman, Napier, O'Brien, & Childress, 2001). In a sample of cocaine users, Monterosso and colleagues (2001) found little correlation between self-report measures of impulsivity and GT performance and a moderate correlation between GT performance and intellectual functioning. In frontal lobe patients, GT scores appear to be independent of overall intellectual functioning (Bechara, Tranel et al., 2000).

As of this date, only one study has looked at the GT in adults with ADHD symptoms. Perretta and Beninger (2004) compared 19 college students with ADHD symptoms to 20 normal controls on a set of executive functioning tasks, including the GT. Both groups decreased disadvantageous responding on the GT across trials and had comparable performance on most executive functioning measures. The ADHD group performed more poorly on a test of set maintenance than did controls. The ADHD group was described as "high functioning" and free of depression symptoms.

Vocabulary

The *Vocabulary* subtest of the WAIS-III (Wechsler, 1997) consists of 33 items and asks participants to define a list of increasingly difficult words. Participant responses are scored on a 3-point scale (2 = correct, 1 = partially correct, 0 = incorrect). Total raw scores range from 0 to 61. The task provides a good estimate of overall intelligence, as it loads strongly on a General Intelligence factor and has the highest correlation, compared to other WAIS-III subtests, with the Full Scale Intelligence Quotient (IQ; Lezak, 1995; Tulsky et al., 1997). For adults between ages 18 to 34 years, Vocabulary correlates approximately .90 with Verbal IQ and .85 with Full Scale IQ (Tulsky et al., 1997). Average test–retest stability scores for Vocabulary scores are excellent (ranging from .89 to .93) and are among the highest among the WAIS-III subscales (Tulsky et al., 1997). In the current study, the Vocabulary test corresponds to the crystallized intelligence/nonexecutive functioning tests used in previous ego depletion research (e.g., Schmeichel et al., 2003).

Post-Experimental Questionnaire

Consistent with the previous ego depletion research (e.g., Baumeister, Bratslavsky et al., 1998; Muraven et al., 1999; Muraven et al., 1998), participants completed a post-experimental questionnaire (Research Experience Questionnaire; REQ) to assess manipulation effects. On 7-point Likert-type scales (anchored at 1 = "very little" and 7 = "a lot"), participants were asked to indicate the effort they exerted on the experimental tasks, how much fatigue they felt, etc. The REQ items are presented in Appendix D.

Design and Procedure

Pilot Study

Prior to the main study, pilot data were collected to prepare the experimental methodologies (e.g., estimate time for questionnaires and protocols), train examiners, and to offer a preliminary test of experimental hypotheses. Thirty-four adults participated in the study. Most were undergraduate students (n = 30) taking introductory psychology at the UM and received experimental course credits for their participation; four participants were graduate students in the UM Clinical Psychology program. The CPT and AR groups were relatively equivalent in terms of gender, age, and ethnicity. The mean age 22.28 years (SD = 4.55), 51 percent were male, and 69.7 percent were Caucasian

Main Study

The current study employed a 2 x 2 between-subjects factorial design. Participants reporting ADHD symptoms (ADHD group) and Non-ADHD participants were randomly assigned to either a Depletion CPT or Non-Depletion Arithmetic protocol. The examiners who conducted the experiment were trained by me and were blind to both group membership (ADHD or Non-ADHD) and study hypotheses.

Recruitment and Matching

Data collection took approximately 20 months, from March 2003 to October 2004. Participants with ADHD symptoms (ADHD participants) were recruited through the following means: letters sent out by the disability services offices, recruitment posters placed at various locations on the campuses, recruitment announcements in introductory psychology classes, and word of mouth. Non-ADHD participants were mainly recruited through recruitment posters, recruitment announcements in introductory psychology classes, and word of mouth. Potential participants contacted me in person, by telephone, or Email. I briefly interviewed all of the potential participants regarding their background and degree of ADHD symptoms. When feasible, I conducted the interviews in person and administered background and symptom questionnaires. Otherwise, I interviewed potential participants by phone or Email and then had them complete questionnaires in a waiting room prior to their participation in the study. I then reviewed/scored their questionnaire responses and randomly assigned the participants to the experimental groups.

Consistent with procedures use in previous self-control studies (e.g., Baumeister, Bratslavsky et al., 1998; Muraven et al., 1998), potential participants were not told that the study was an examination of self-control. Instead, they were told that the study was an examination of university and college students with and without ADHD on problem solving, mood, and physical stamina. Participants were informed that the study would take approximately one hour to complete. Participants enrolled in introductory psychology courses at the UM earned course credits for their participation. Introductory psychology students who did not need course credits, non-introductory psychology students, and non-UM students received a small honorarium.

The initial recruitment was aimed at acquiring individuals with ADHD symptoms and randomly assigning them to the CPT Depletion or AR Non-Depletion conditions. Subsequent recruitment focused on acquiring matched Non-ADHD participants. As indicated above, attempts were made to match individuals in terms of age, gender, and educational faculty. As outlined by Kazdin (1998), Non-ADHD participants were assigned to the *same* conditions (CPT or AR) as their matched ADHD peers.

Protocols

Participants met the examiner in a waiting area in the Student Counselling and Career Centre at the UM and were escorted to the testing room. The room was equipped with a computer and a table. The examiner explained the study (see "Participants" section above), allowed for questions, and had the participant sign a consent form.

In the CPT Depletion protocol, the examiner sat across from the participant and began the study by having the participant complete the handgrip task (Trial 1). Participants were not informed of their handgrip time scores. The examiner then guided the participant over to the computer and instructed them regarding the CPT. The participant was given a chance to practice the CPT, enter demographic data, and then do the test. The CPT took approximately 14 minutes to complete and served as the ego depletion task. The examiner was present in the room as the participant worked on the CPT; however, the examiner was at the far corner of the room "working on paperwork." Following completion of the CPT, the participant returned to the table to complete the Brief Mood Introspection Scale (BMIS) and another trial of the handgrip (Trial 2). The dependent measure on the handgrip task was the net stamina score (Trial 2 minus Trial 1), which provided the first measure of ego depletion. The examiner then took the participant over to the computer to do the Gambling Task (GT). The examiner explained that the goal of the task was to make as much money as possible in the game and to continue to take cards as long as the computer required. The examiner and participant then returned to the table to complete the final task, the WAIS-III Vocabulary subtest. The examiner did not score the Vocabulary, but simply wrote down participant's responses verbatim. I scored results subsequently when reviewing participant data. Finally, upon completion of the Vocabulary test, the participant was asked to complete the REQ, which assessed effort, fatigue, etc. Participants were not debriefed regarding the nature of the study until data collection was complete for all participants.

The procedure, sequence of tasks, and instructions in the Non-Depletion condition were identical to that of the Depletion condition with the exception that participants spent 14 minutes doing arithmetic questions instead of the CPT. Instructions for ADHD and non-ADHD participants were identical in the current study. At the time of initial interview, all participants were asked not to take any medication (e.g., Ritalin) prior to testing, given that this could impact on performance on self-control tasks. In order to reduce experimental bias, examiners did not inquire about medication compliance.

Tasks were presented in a fixed sequence: Handgrip, CPT, BMIS, GT, Vocabulary, and REQ. The handgrip task was presented first because it has been used in because it has little ego-depleting effect on its own (Muraven et al., 1998). Although potentially relevant, sequence effects were not the focus of analysis in the study.

RESULTS

Data Preparation

Data screening and preparation analyses, suggested by Tabachnick and Fidell (2001), were carried out on the Handgrip (HG), Gambling Task (GT), and Vocabulary (Voc) results. GT and Voc results were normally distributed and did not contain any significant outliers. Raw HG scores were non-normally distributed, revealing three univariate outliers. HG data were truncated to a maximum of 150 seconds per trial (i.e., Trial 1 and Trial 2), as this best fit the data, significantly decreased the effect of outliers, and led to acceptable normal distributions of HG change scores (i.e., Trial 2 minus Trial 1; J. Clark, personal communication, January 10, 2005). Where appropriate, missing data were replaced by group mean scores.

Participant Characteristics

As noted, 54 participants reported having significant childhood symptoms consistent with ADHD (ADHD group), and 54 were peers matched in age, gender, and educational faculty (e.g., Arts, Science; Non-ADHD group). Table A1 in Appendix A provides a summary of the participant groups in terms of demographic characteristics.

ADHD Symptom Group Participants

Thirty-six participants (66%) in the ADHD group reported formal diagnoses of ADHD; the others reported both childhood and ongoing symptoms suggestive of ADHD, but no formal diagnoses. Many of non-diagnosed participants reported family histories of ADHD, being worried about their symptoms (e.g., poor academic functioning), and being in various stages of help-seeking (e.g., awaiting a psychological assessment).

Table A2 in Appendix A summarizes the responses of the participants reporting ADHD diagnoses. Approximately 50 percent of the participants were diagnosed in adulthood. Forty percent reported having sought help or assessment on their own. Psychologists and psychiatrists were the most common providers of diagnoses. Interviews, questionnaires, and psychological testing were the most common methods of assessment and diagnosis. Two-thirds reported ADHD-NOS type diagnoses, 28 percent reported ADHD Inattentive type, and 17 percent reported ADHD Combined type diagnoses. Many participants reported family histories of ADHD in parents, siblings, and other biological relatives. Almost half reported taking medication to help manage their symptoms; one-third reported taking stimulant medication. Fifty percent reported not currently taking any medication for the disorder. Many of these participants reported having used medication in childhood; others reported not taking medication due to discomfort with side-effects or due to a desire to "manage symptoms" on their own.

Comparison of ADHD and Non-ADHD Groups

Tables A3 to A6 in Appendix provide comparisons between ADHD and Non-ADHD participants on a number of psychological and behavioral measures. Compared to Non-ADHD participants, ADHD participants reported more childhood symptoms of ADHD on the ABC-C and the WURS, more ongoing symptoms on the ABC-A, more self-control difficulties on the SCS, and more symptoms of depression on the CES-D (Table A3).[23] On the background questionnaire, ADHD participants reported being in

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[23] Measures of ADHD symptoms (ABC-C, ABC-A, and WURS), self-control difficulty (SCS), and depression (CES-D) were highly intercorrelated. The ADHD measures and the SCS correlated in the $r = .72$ to $.89$ range ($p < .01$), and the CES-D correlated in the $r = .55$ to $.64$ range ($p < .01$) with adult ADHD and SCS scores. The scales essentially loaded on one self-control/depressed mood factor.

poorer physical health, having poorer appetite, poorer sleep, less social support, and more difficulty dealing with stress (Table A4). ADHD participants reported greater caffeine use, alcohol use, and smoking. In terms of academic functioning, ADHD participants reported lower high school grades and university/college GPA scores, more academic failures, and lower academic satisfaction (Table A5). ADHD participants reported academic difficulties related to procrastination, poor attention, poor time management, low motivation, and poor organization (Table A5). Finally, ADHD participants reported greater stress from poor grades/coursework, poor time management, poor organization, and psychological distress (e.g., depression) (Table A6).

Performance on Protocol Measures

Consistent with the selection criteria and hypothesized ADHD difficulties, ADHD and Non-ADHD participants differed in their performance on the protocol tasks used in the current study. ADHD participants exhibited more omission errors (i.e., inattention) on the CPT, $\Delta M = 1.27$, $SE = .70$, $t = 1.83$, $p = .037$, $\eta^2 = .06$; a higher CPT Index (i.e., inconsistent performance/overall impairment), $\Delta M = 5.69$, $SE = 1.35$, $t = 4.21$, $p < .001$, $\eta^2 = .25$; and more commission errors (i.e., impulsivity), $\Delta M = 2.60$, $SE = 2.13$, $t = 1.23$, $p = .113$, $\eta^2 = .03$. On Arithmetic (AR), the groups did not differ in number of math items attempted, $\Delta M = -2.07$, $SE = 1.80$, $t = -1.16$, $p = .127$, $\eta^2 = .03$; however, ADHD participants performed more poorly in terms of percent correct (e.g., inattentiveness/ carelessness), $\Delta M = -10.27$, $SE = 5.76$, $t = -1.78$, $p = .041$, $\eta^2 = .06$.

Taken together, the background information, reports of academic and psychosocial functioning, and protocol performance indicated that the ADHD and Non-ADHD groups showed meaningfully different clinical presentations. The difficulties reported by the ADHD group were consistent with the disorder.

Main Hypotheses

Hypothesis 1 predicted that there would be an overall Protocol main effect: the CPT Depletion group would exhibit more evidence of ego depletion on dependent measures (e.g., net handgrip, decision-making) than the AR Non-Depletion group. Hypothesis 2 predicted an overall Group effect: ADHD participants would exhibit poorer performance on dependent measures than Non-ADHD participants. Hypothesis 3 predicted a Protocol x Group interaction, with the ADHD/CPT group exhibiting the poorest performance on dependent measures and the Non-ADHD/AR exhibiting the best performance. Hypotheses also predicted that crystallized verbal intelligence (i.e., Vocabulary) would be relatively immune from depletion effects.

For all of the main variables, the results were analyzed by 2 (Protocol; AR Non-Depletion vs. CPT Depletion) by 2 (Group; Non-ADHD vs. ADHD) ANOVAs. Where appropriate, ANOVAs were followed by single-degree of freedom pairwise contrasts to further elucidate the results. As outlined by Jaccard and Guilamo-Ramos (2002a; 2002b), single-degree of freedom contrasts were computed using the mean standard error for the entire sample. Significance testing of the contrasts used an alpha level set at .05 in conjunction with a modified a Bonferroni procedure to minimize expermentwise error.[24]

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[24] The current study utilized the modified Bonferroni method outlined by Holm (1979; cited in Jaccard & Guilamo-Ramos, 2002) to minimize Type I error. The modified Bonferroni method is more powerful than the traditional Bonferroni method while maintaining expermentwise error rates at a desired alpha level. In the modified procedure, *p* values are obtained for a family of contrasts and are then rank "ordered from smallest to largest. . . . The contrast with the smallest *p* value is evaluated against an alpha of $.05/k$, where k is the total number of contrasts in the family. If this leads to rejection of the corresponding null hypothesis (because the observed *p* value is less than the adjusted α), then the next smallest *p* value is tested against an alpha level of $.05/(k-1)$, where $k-1$ is the remaining number of contrasts. If this test leads to null hypothesis rejection, then the next smallest *p* value is tested against an alpha level of $.05/(k-2)$, and so on until a nonsignificant difference is observed. Once a statistically nonsignificant difference is observed, all remaining contrasts are declared nonsignificant" (p. 143).

Handgrip Task

As noted, the Handgrip task yields a stamina change score, HG-Net, computed by subtracting handgrip performance at Trial 2 (seconds) from handgrip performance at Trial 1 (seconds). Negative HG-Net values indicate decreased self-control strength (i.e., resource or ego depletion), scores close to zero suggest no loss of self-control strength, and positive scores suggest increased self-control strength (e.g., practice effect).[25]

HG-Net results are illustrated in Figure 1. Overall, the participants exhibited a small decrease in physical stamina on the handgrip task, with an average decrease across all conditions ($M = -5.58$ sec, $SD = 22.32$). Protocol (Non-Depletion vs. Depletion), Group (Non-ADHD vs. ADHD), and the interaction of the two variables appeared to influence handgrip task performance.

The main effect of Protocol on HG-Net scores was statistically nonsignificant. The HG-Net scores of participants in the CPT Depletion protocol ($M = -8.85$ sec, $SD = 20.34$) were not significantly lower than those of participants in the AR Non-Depletion protocol ($M = -2.31$ sec, $SD = 23.87$), $F = 2.48$, $df = 1, 107$, $p = .118$, $\eta^2 = .02$.

Contrary to experimental hypotheses, there was no significant main effect of Group on HG-Net scores. Non-ADHD participants ($M = -6.67$ sec, $SD = 22.49$) exhibited equivalent HG-Net scores to those of ADHD participants ($M = -4.49$ sec, $SD = 22.30$), $F = .27$, $df = 1, 107$, $p = .603$, $\eta^2 = .02$.

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[25] Time 1 (pre) and Time 2 (post) handgrip performance scores were also examined in order to compare the performance of participants. The results were consistent with the HG-Net results reported in this section. ANOVA results for Time 1 scores indicated no significant main effects or interaction effects (p values ranging from .766 to .985). The four groups had relatively equal Time 1 scores. ANOVA results for Time 2 scores were also nonsignificant (p values ranging from .130 to .966). The pattern of Time 2 scores suggested that Non-ADHD participants had lower stamina in the CPT Depletion condition than in the AR Non-Depletion condition (i.e., ego depletion). ADHD participants had relatively equal scores in the Depletion and Non-Depletion conditions.

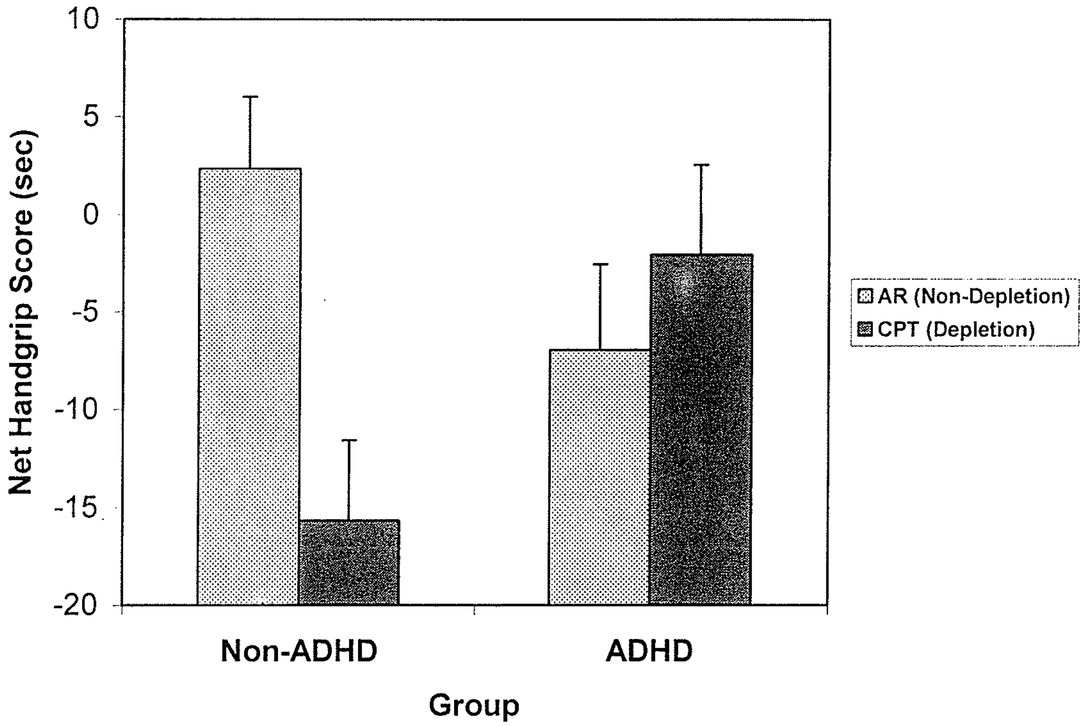

Figure 1. Net Handgrip task scores (sec) as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.**

Most central to the purpose of this study was the observation of a statistically significant interaction between Protocol and Group. As hypothesized, the effect of Protocol differed for Non-ADHD and ADHD participants, $F = 7.62$, $df = 1, 107$, $p = .007$, $\eta^2 = .07$. Surprisingly, inspection of the condition means (see Figure 1) suggested that the expected effect of Protocol on HG-Net scores occurred only for Non-ADHD participants. The Protocol effect was essentially non-existent for ADHD participants.

Follow-up pairwise comparisons indicated that the only statistically significant group difference was between Non-ADHD participants in the CPT Depletion and AR Non-Depletion conditions. Consistent with previous research, Non-ADHD participants in the Depletion condition ($M = -15.67$ sec, $SD = 22.52$) exhibited lower HG-Net scores (more ego depletion) than Non-ADHD participants in the Non-Depletion condition ($M = 2.34$ sec, $SD = 18.85$), $\Delta M = -18.01$, $SE = 5.88$, $t = -3.07$, $p = .003$, $\eta^2 = .08$.

The only other pairwise comparison that approached statistical significance was the difference between Non-ADHD participants and ADHD participants in the CPT Depletion protocol. Contrary to experimental hypotheses, Non-ADHD participants in the Depletion condition ($M = -15.67$ sec, $SD = 22.52$) exhibited lower HG-Net scores (more ego depletion) than ADHD participants in the Depletion condition ($M = -2.03$ sec, $SD = 23.62$), $\Delta M = -13.64$, $SE = 5.87$, $t = -2.32$, $p = .011$, $\eta^2 = .05$.

One remaining contrast is worth mentioning: the comparison between Non-ADHD and ADHD participants in the AR Non-Depletion condition. Although not statistically significant, there was a trend in the hypothesized direction for Non-ADHD participants in Non-Depletion condition ($M = 2.34$ sec, $SD = 18.85$) to have higher HG-Net scores (less ego depletion) than ADHD participants in the Non-Depletion condition ($M = -6.95$ sec, $SD = 21.06$), $\Delta M = 9.30$, $SE = 5.87$, $t = 1.58$, $p = .058$, $\eta^2 = .02$. These results are consistent with Hypothesis 3.

Comparisons Against Zero

Previous ego depletion research has compared the HG-Net scores of the study groups against zero (1) to rule out other effects (e.g., practice effects) that might explain group differences (e.g., improved HG-Net scores in the AR condition, as opposed to lower HG-Net scores in the CPT condition; Muraven et al., 1998) and (2) to provide additional support for main hypotheses. Consistent with Hypothesis 1, the overall mean of the AR Non-Depletion group was not significantly different from zero (i.e., no ego depletion; ΔM = -2.31 sec, SD = 20.34, t = -.83, p = .41, d = .11), whereas the overall mean of the CPT Depletion group was significantly below zero (i.e., ego depletion; ΔM = -8.85 sec, SD = 23.87, t = -2.72, p = .009, d = .37).[26] Similarly, the mean of the Non-ADHD participants in the AR Non-Depletion condition was not significantly different from zero (i.e., no ego depletion; ΔM = 2.34 sec, SD = 18.85, t = .65, p = .52, d = .12), whereas the overall mean of the Non-ADHD participants in the CPT Depletion group was significantly below zero (i.e., ego depletion; ΔM = -15.67 sec, SD = 22.52, t = -3.62, p = .001, d = .70). Taken together, the results did not support alternate hypotheses for group differences and provided additional support for Hypothesis 1.

[26] Comparisons against zero were analyzed using 2-tailed t tests, as directional hypotheses could not be made for all variables. However, it was hypothesized that certain participants groups (e.g., all ADHD participants) would show evidence of resource depletion (i.e., have negative HG-Net scores).

Gambling Task

As noted previously, the current study used the Gambling Task net A-B score (GT-AB) as the key indicator of task performance. GT-AB is a change score of the frequency of choosing cards from disadvantageous decks A and B across trials (i.e., the frequency total of A-B responses from trials 76 to 100 minus the frequency total of A-B responses from trials 1 to 25). Lower or negative GT-AB scores indicate decreased disadvantageous responding (i.e., improved decision making) across learning trials.

Overall, participants exhibited a decrease in disadvantageous responding on the Gambling Task across trials in the four experimental conditions ($M = -2.86$, $SD = 5.97$). The GT-AB results are summarized in Figure 2.

Consistent with Hypothesis 2, the main effect of Group on GT-AB scores was statistically significant. ADHD participants ($M = -1.06$, $SD = 6.78$) exhibited higher GT-AB scores (i.e., greater difficulty inhibiting disadvantageous responding) than Non-ADHD participants ($M = -4.67$, $SD = 4.39$), $F = 10.85$, $df = 1, 107$, $p = .001$, $\eta^2 = .09$.

Contrary to Hypothesis 1, there was no significant effect of Protocol on GT-AB scores. The GT-AB scores of participants in the AR Non-Depletion condition ($M = -3.39$, $SD = 5.15$) were not significantly different from those of participants in the CPT Depletion condition ($M = -2.33$, $SD = 6.70$), $F = .93$, $df = 1, 107$, $p = .338$, $\eta^2 = .01$. Similarly, the Protocol x Group interaction was also nonsignificant, $F = 1.69, 27$ ($df = 1, 107$, $p = .196$, $\eta^2 = .02$.

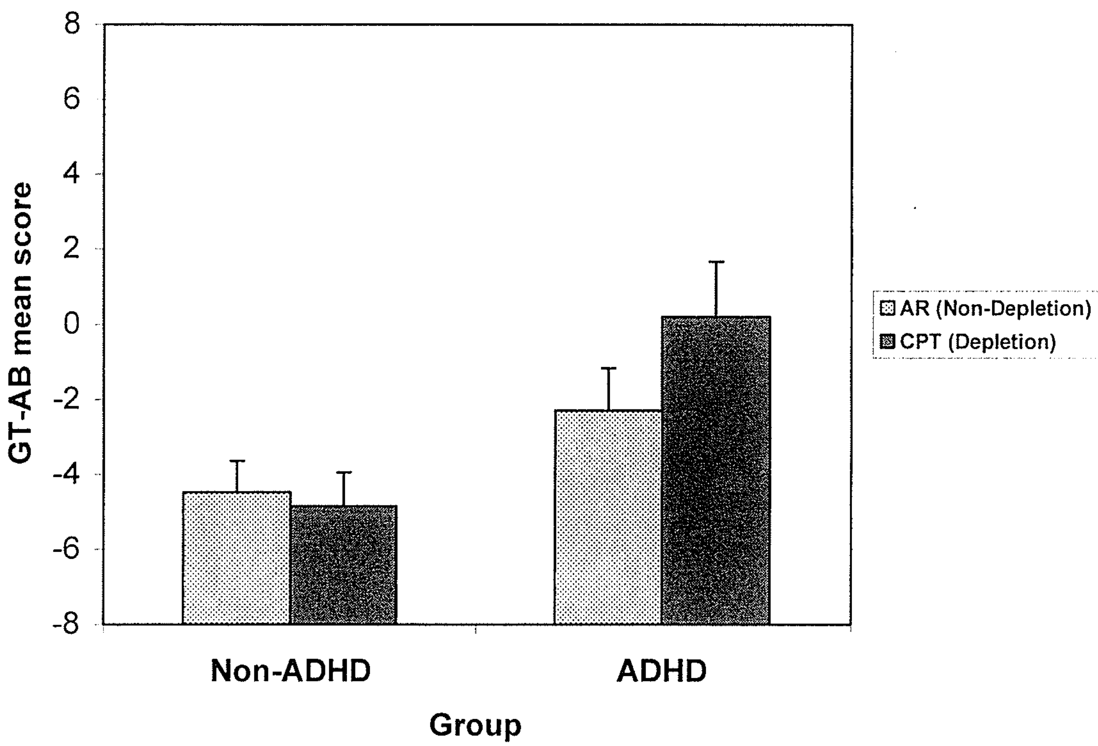

Figure 2. Gambling Task A-B scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.**

Only two post-hoc pairwise contrasts were significant.[27] Consistent with Hypothesis 3, Non-ADHD participants in the AR Non-Depletion condition (M = -4.48, SD = 4.26) exhibited significantly lower GT-AB scores than ADHD participants in the CPT Depletion condition (M = 0.19, SD = 7.56), ΔM = -4.67, SE = 1.55, t = 3.01, p = .002, η^2 = .08. Similarly, Non-ADHD participants in the CPT Depletion protocol (M = -4.85, SD = 4.60) exhibited significantly lower GT-AB scores than ADHD participants in the CPT Depletion protocol (M = 0.19, SD = 7.56), ΔM = -5.04, SE = 1.55, t = 3.25, p = .001, η^2 = .09. No other post-hoc contrasts were statistically significant.

Comparisons Against Zero

As noted above, the GT-AB scores of the study groups were compared against zero to provide additional support for the main hypotheses. Both the overall means of the AR Non-Depletion group (i.e., no ego depletion; ΔM = -3.39, SD = 5.15, t = -4..83, p < .001, d = .66) and the CPT Depletion group (ΔM = -2.33, SD = 6.70, t = -2.56, p = .01, d = .35) were significantly different from zero. Overall, both groups decreased disadvantageous responding (i.e., negative GT-AB scores). The GT-AB scores of ADHD participants in the AR Non-Depletion group were significantly different from zero (ΔM = -2.30, SD = 5.79, t = -.2.06, p = .049, d = .39), whereas the scores of ADHD participants in the CPT Depletion group were not significantly different from zero (ΔM = .19, SD = 7.56, t = .13, p = .900, d = .03). These results are consistent with Hypotheses 1 and 3.

Consistent with Hypothesis 2, the overall mean of ADHD participants was not significantly different from zero (ΔM = -1.06, SD = 6.78, t = -.1.14, p = .258, d = .16), whereas the mean of Non-ADHD participants was significantly different from zero (ΔM

[27] Simple effect contrasts are acceptable in the absence of a significant interaction, when the comparisons are central to experimental hypotheses (Jaccard & Guilam-Ramos, 2002a; 2002b; Maxwell & Delaney, 1999). As noted, post hoc comparisons were evaluated using a modified Bonferroni method to minimize expermentwise error.

= -4.67, *SD* = 4.39, t = -7.81, p = <.001, d = 1.06).

Vocabulary

As noted previously, the Vocabulary subtest yields one raw score, with higher scores indicating greater knowledge of word meanings and crystallized verbal intelligence. Figure 3 summarizes the Vocabulary results. Consistent with experimental hypotheses, there were no statistically significant differences between the groups. ANOVA results did not indicate statistically significant effects for Protocol (F = 1.00, df = 1, 107, p = .319, η^2 = .01), Group (F = 1.05, df = 1, 107, p = .307, η^2 = .01), or Protocol x Group interaction (F = .15, df = 1, 107, p = .698, η^2 <.01). Given the lack of significant results, no additional analyses were performed.

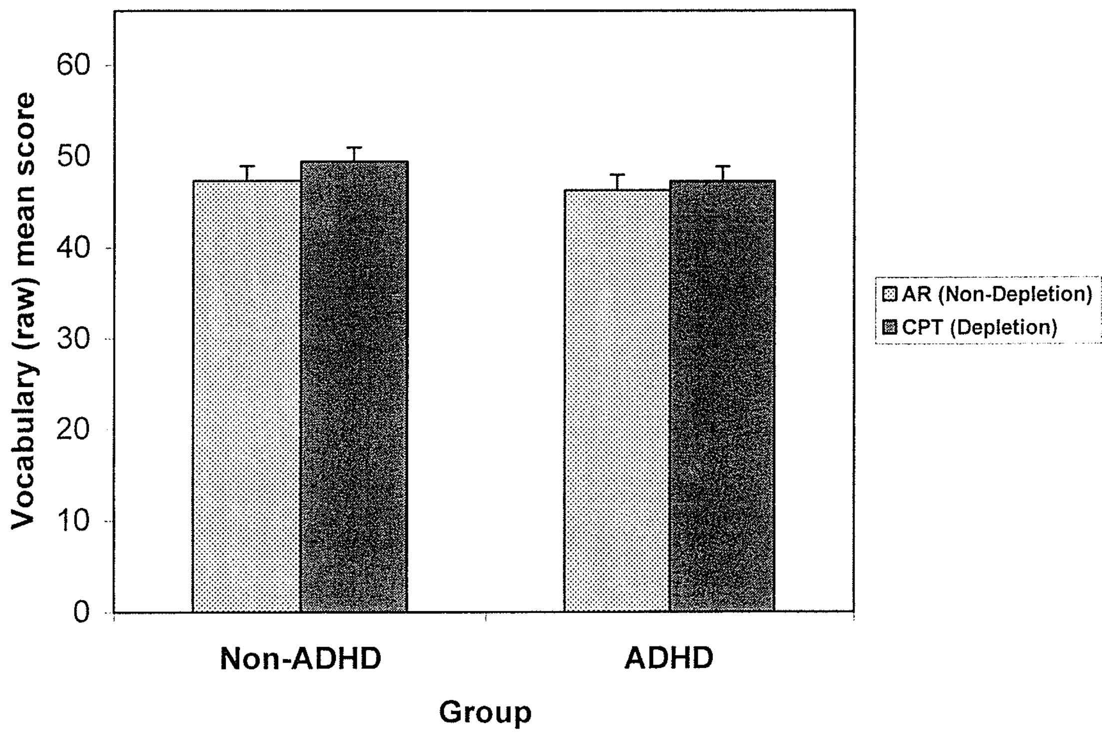

Figure 3. Vocabulary raw scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.**

Manipulation Checks

Previous self-control research has examined a variety of manipulation effects to support the self-control resource strength model and to rule-out alternate hypotheses. The following sections address the manipulation checks used in previous research: participants' self-reported mood, arousal, fatigue, effort, and task difficulty.

Mood

Participants' mood was assessed using the Brief Mood Introspection Scale Pleasant-Unpleasant (BMIS-PU) score, with higher scores indicating more positive or pleasant mood. Based on previous research, it was not expected that BMIS-PU scores would differ across experimental protocols; however, it was hypothesized that Non-ADHD participants would report higher BMIS-PU scores than ADHD participants.

Consistent with the hypotheses, there was a significant main effect of Group on BMIS-PU scores, $F = 12.74$ ($df = 1, 107, p = .001, \eta^2 = .11$). Non-ADHD participants ($M = 75.61$, $SD = 12.46$) reported significantly higher mood scores (i.e., more positive mood) than ADHD participants ($M = 65.56$, $SD = 16.37$). As expected, there was no significant main effect for Protocol on BMIS-PU scores, $F = .51$ ($df = 1, 107, p = .475, \eta^2 = .01$). The mood scores of the AR Non-Depletion participants ($M = 71.59$, $SD = 17.12$) did not differ from those of the CPT Depletion participants ($M = 69.57$, $SD = 13.40$). The Protocol x Group interaction was also not significant, $F = .10$ ($df = 1, 107, p = .758, \eta^2 = <.01$). The BMIS-PU results are summarized in Figure 4.

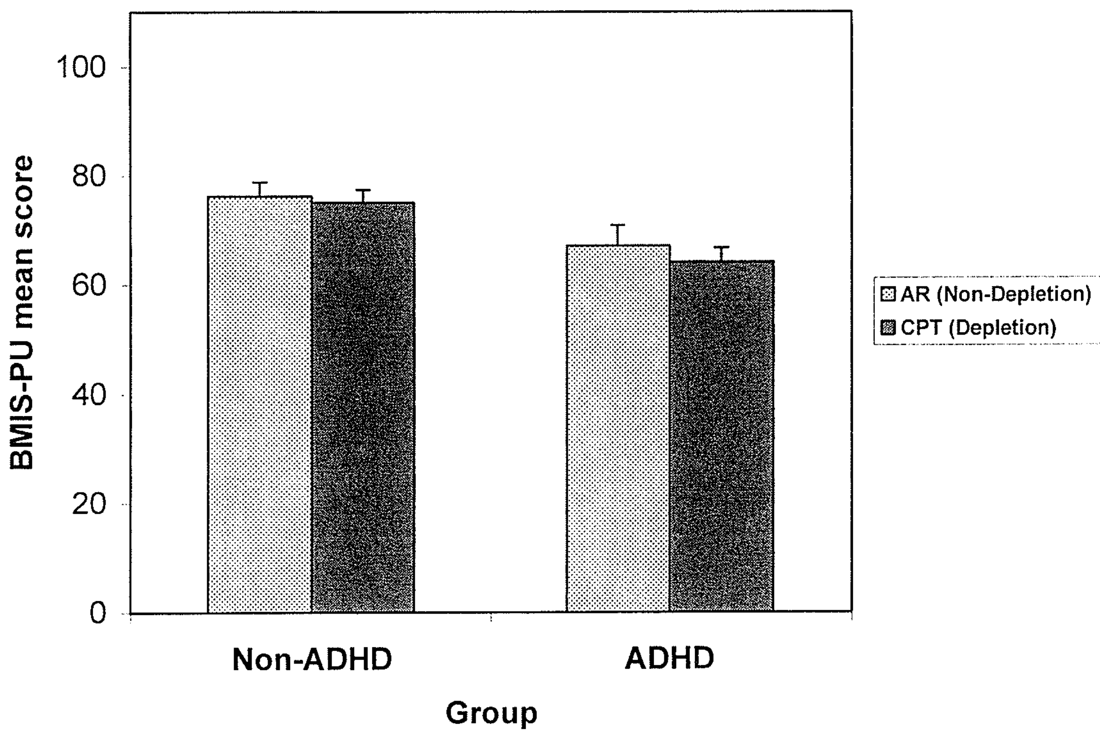

Figure 4. BMIS Pleasant-Unpleasant (BMIS-PU) mood scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test. BMIS = Brief Mood Introspection Scale.**

Arousal

Participants' arousal was assessed using the Brief Mood Introspection Scale Aroused-Calm (BMIS-AC) score, with higher scores indicating more arousal or irritability. Based on previous research, it was not expected that BMIS-AC scores would differ across experimental protocols; however, it was hypothesized that Non-ADHD participants would report lower BMIS-AC scores than ADHD participants.

Consistent with the hypotheses, there was a significant main effect of Group on BMIS-AC scores, $F = 5.32$ ($df = 1, 107$, $p = .023$, $\eta^2 = .05$). Non-ADHD participants ($M = 30.11$, $SD = 6.86$) reported significantly lower arousal levels than ADHD participants ($M = 33.26$, $SD = 7.25$). As expected, there was no significant main effect for Protocol on BMIS-PU scores, $F = .36$ ($df = 1, 107$, $p = .552$, $\eta^2 <.01$). The arousal scores of the AR Non-Depletion participants ($M = 32.09$, $SD = 5.99$) did not differ significantly from those of the CPT Depletion participants ($M = 31.28$, $SD = 8.27$). The Protocol x Group interaction was also not significant, $F = .58$ ($df = 1, 107$, $p = .449$, $\eta^2 = .01$). The BMIS-AC results are summarized in Figure 5.

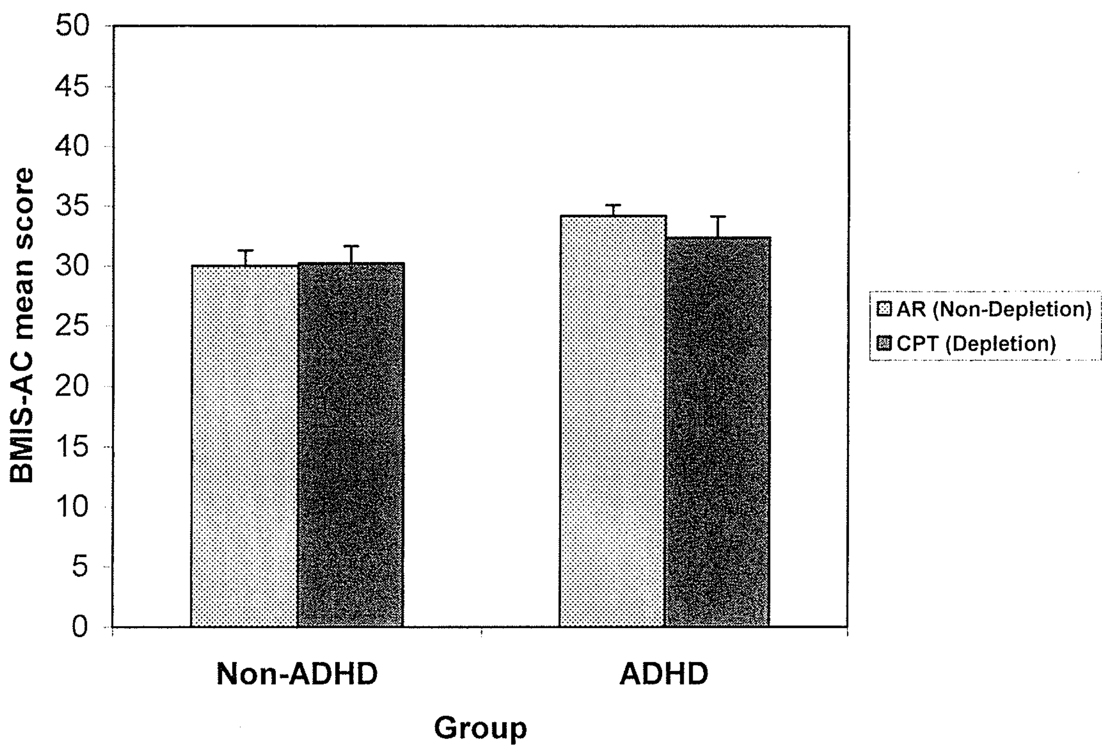

Figure 5. BMIS Aroused-Calm (BMIS-AC) arousal scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test. BMIS = Brief Mood Introspection Scale.**

Fatigue

Previous self-control strength research suggests that fatigue may be elevated in the Depletion condition. The current study utilized a composite measure of fatigue obtained from the sum of BMIS items measuring fatigue (e.g., *tired* and *drowsy*) and one similar item obtained from the post-experimental research questionnaire (Research Experience Questionnaire [REQ] item 6 asking participants how tired they felt after completion of protocol tasks).[28] Based on previous research, it was hypothesized that (1) participants in the CPT Depletion protocol might report more fatigue than participants in AR Non-Depletion protocol, (2) ADHD participants would report more fatigue than Non-ADHD participants, and (3) there would be significant Protocol by Group interaction (i.e., ADHD/CPT participants reporting the most fatigue and/or Non-ADHD/AR participants reporting the least fatigue). Figure 6 summarizes the fatigue results.

Consistent with Hypothesis 1, there was a significant main effect for Protocol on fatigue scores, $F = 7.17$ ($df = 1, 107$, $p = .009$, $\eta^2 = .06$). Participants in the CPT Depletion group ($M = 12.70$, $SD = 4.48$) reported significantly more fatigue than participants in the AR Non-Depletion group ($M = 10.44$, $SD = 4.48$).

Consistent with Hypothesis 2, there was a significant main effect for Group on fatigue scores, $F = 7.17$ ($df = 1, 107$, $p = .009$, $\eta^2 = .06$). ADHD participants ($M = 12.70$, $SD = 4.48$) reported significantly more fatigue than Non-ADHD participants ($M = 10.44$, $SD = 4.48$).

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[28] The creation of a composite measure was justified based on a significant correlation between BMIS-F and REQ-6 ($r = .47$, $p < .001$) and on principal components analysis results indicating that the two BMIS items (*drowsy* and *tired*) and REQ-6 all loaded on one factor (unrotated factor loadings: *drowsy*, .82; *tired*, .89; and *fatigue*, .73), accounting for over 66% of the variance. The isolation of the two fatigue items from the BMIS was approved by one of the scale authors (personal communication, J. Mayer, February 2, 2005).

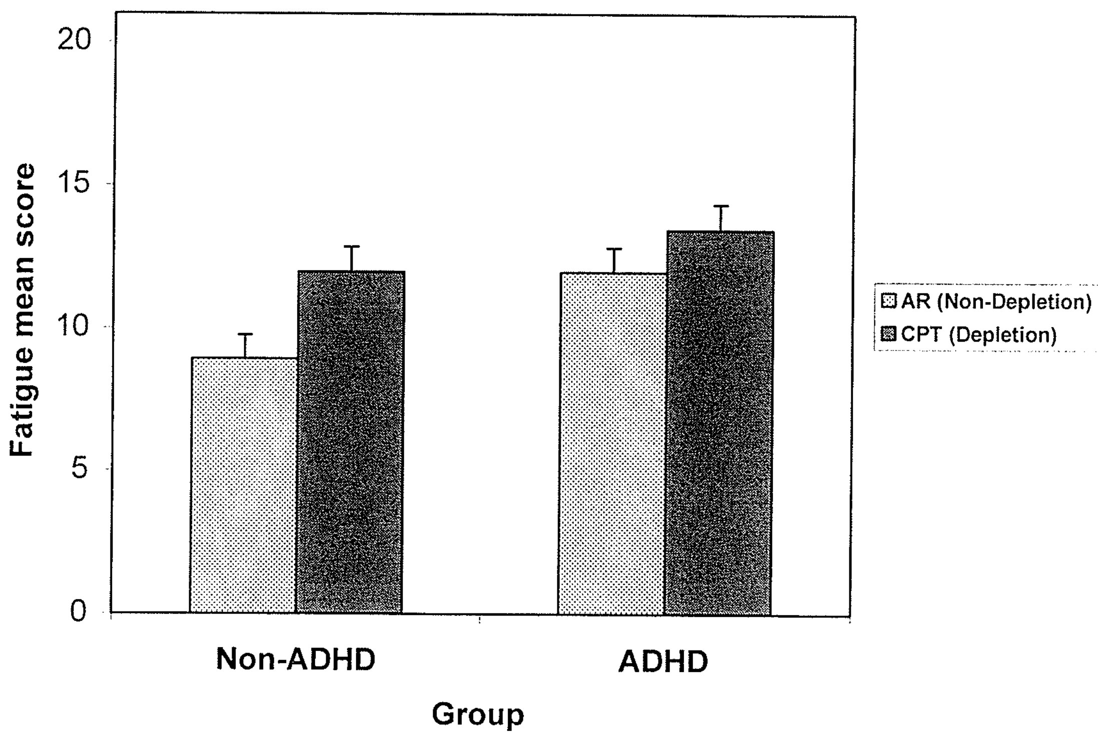

Figure 6. Fatigue scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). *Notes:* error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.

The Protocol x Group interaction was not significant, $F = .85$ ($df = 1, 107$, $p = .359$, $\eta^2 = .01$). Although the interaction was not significant, the results were consistent with Hypothesis 3. As expected, follow-up single-degree of freedom contrasts indicated that ADHD participants in the CPT Depletion group ($M = 13.44$, $SD = 4.58$) reported significantly more fatigue than Non-ADHD participants in the AR Non-Depletion group ($M = 8.93$, $SD = 4.18$), $\Delta M = -4.52$, $SE = 1.19$, $t = 3.79$, $p < .001$, $\eta^2 = .12$. Moreover, the Non-ADHD participants in the AR Non-Depletion group had lower fatigue scores than Non-ADHD participants in the CPT Depletion group ($M = 11.96$, $SD = 4.45$; $\Delta M = -3.04$, $SE = 1.19$, $t = 2.54$, $p = .006$, $\eta^2 = .06$) and ADHD participants in the AR Non-Depletion group ($M = 11.96$, $SD = 4.33$; $\Delta M = -3.04$, $SE = 1.19$, $t = 2.54$, $p = .006$, $\eta^2 = .06$).

Effort and Motivation

It was hypothesized that participants would put relatively equivalent levels of effort into the experimental tasks. Effort and motivation were assessed by a composite measure obtained the post-experimental questionnaire: REQ-1 (*how much effort did you put into the task*), REQ-2 (*how hard did you work on the task*), and REQ-9 (*how motivated were you to do well on the task*). The three items comprised one effort-motivation factor.[29]

As expected, there were no statistically significant differences between the groups (see Figure 7). ANOVA results did not indicate statistically significant effects for Protocol ($F = 1.00$, $df = 1, 107$, $p = .319$, $\eta^2 = .01$), Group ($F = 1.05$, $df = 1, 107$, $p = .307$, $\eta^2 = .01$), or Protocol x Group interaction ($F = .15$, $df = 1, 107$, $p = .698$, $\eta^2 <.01$).

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[29] REQ scores (items 1 to 10) were analyzed through correlation analyses, scree plots, and principal component analysis. The rotated factor loadings for the effort-motivation items were as follows: REQ-1 (effort), .890; REQ-2 (hard work), .876; and REQ-9 (motivation), .687. The factor accounted for approximately 25% of the variance in REQ scores.

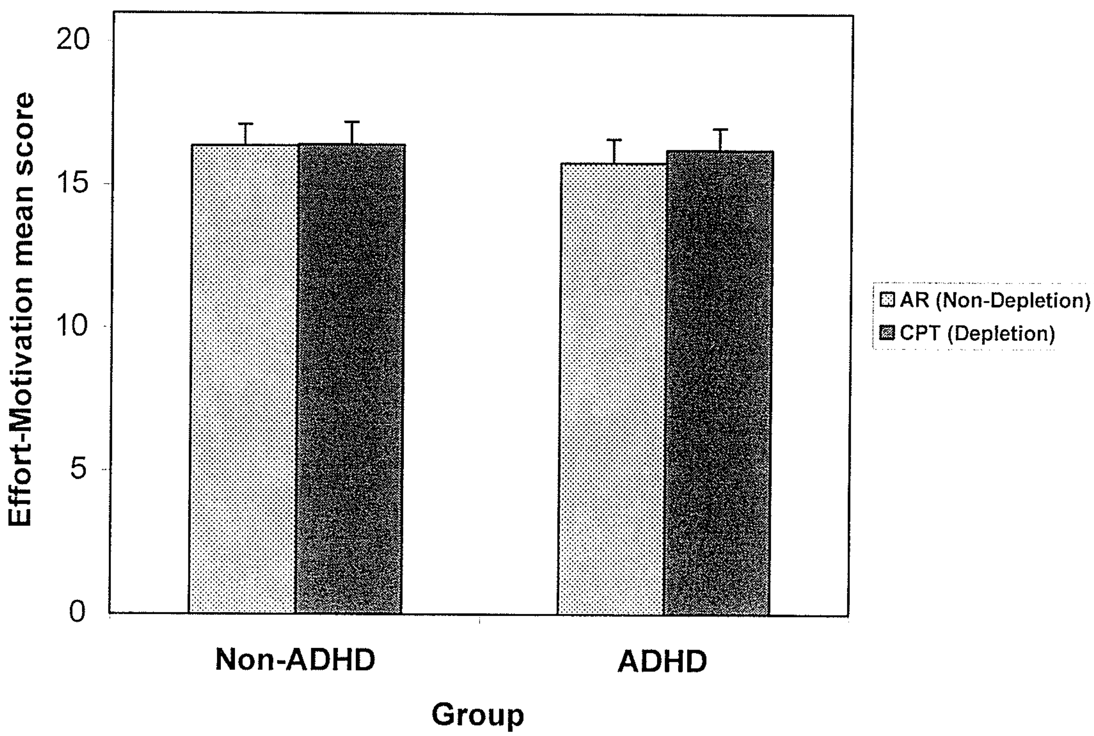

Figure 7. Effort-Motivation scores as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.**

Task Difficulty

The final manipulation check item evaluated in the current study was perceived task difficulty. Based on previous self-control strength research, it was hypothesized that participants in the CPT Depletion protocol would find the task more difficult than participants in the AR Non-Depletion protocol. It was also hypothesized that ADHD participants would find the protocol tasks more difficult than Non-ADHD participants and that there would be a significant Protocol x Group interaction (i.e., ADHD/CPT participants reporting the most task difficulty and/or Non-ADHD/AR participants reporting the least task difficulty). Perceived task difficulty was obtained from the sum of two post-experimental questionnaire items, REQ-4 (*how difficult did you find the task*) and REQ-3 (*how much energy did the tasks require*).[30] Task difficulty results are summarized in Figure 8.

Consistent with Hypothesis 2, the main effect of Group on task difficulty was statistically significant, $F = 9.99$, $df = 1, 107$, $p = .002$, $\eta^2 = .09$. ADHD participants ($M = 9.78$, $SD = 2.94$) reported more task difficulty than Non-ADHD participants ($M = 7.91$, $SD = 3.21$).

Contrary to Hypothesis 1, the effect of Protocol on task difficulty was not statistically significant, $F = 1.65$, $df = 1, 107$, $p = .202$, $\eta^2 = .02$. The task difficulty scores of participants in the AR Non-Depletion condition ($M = 8.46$, $SD = 3.36$) were not significantly different from those of participants in the CPT Depletion condition ($M = 9.22$, $SD = 3.01$).

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[30] REQ-4 and REQ-5 were correlated significantly positively, $r = .49$, $p < .001$. The respective unrotated factor loadings for the items were .90, accounting for approximately 80% of the variance.

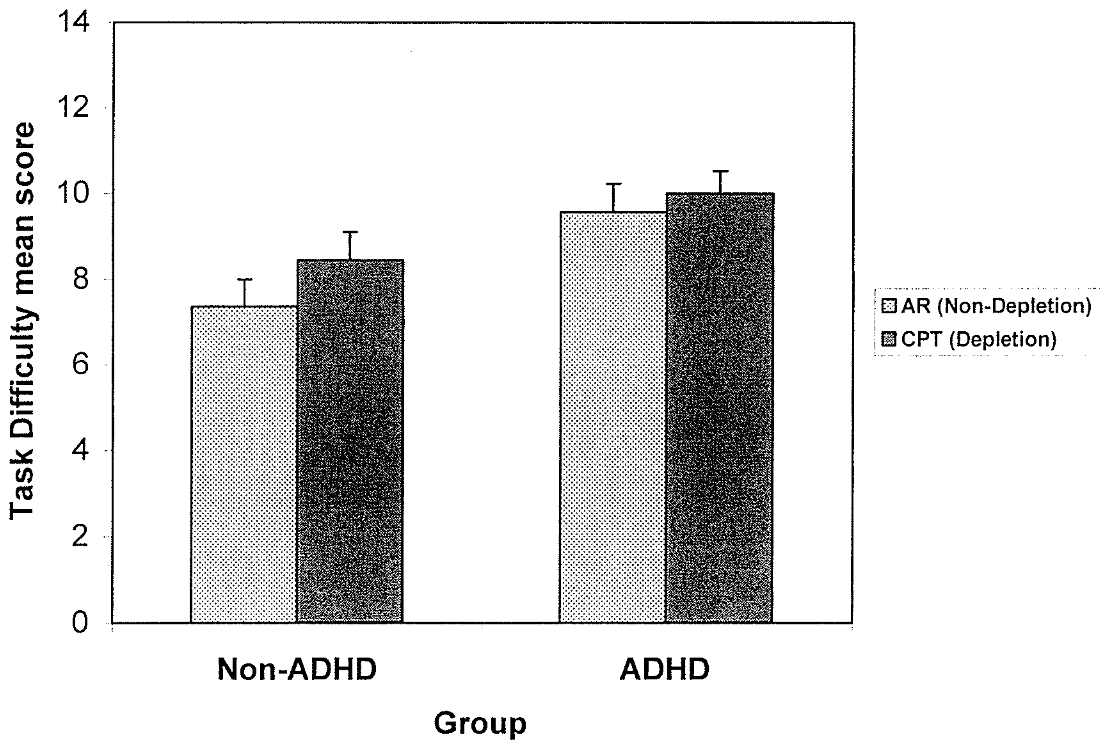

Figure 8. Perceived task difficulty as a function of Group (Non-ADHD vs. ADHD) and Protocol (AR Non-Depletion vs. CPT Depletion). ***Notes:*** **error bars represent standard errors. N =27 per group. ADHD = Attention-Deficit Hyperactivity Disorder. AR = Arithmetic. CPT = Conners' Continuous Performance Test.**

The Protocol x Group interaction was not significant, $F = .28$ ($df = 1, 107$, $p = .596$, $\eta^2 < .01$). While the interaction was not significant, the pattern of results was consistent with Hypothesis 3. As expected, follow-up single-degree of freedom contrasts indicated that Non-ADHD participants in the AR Non-Depletion group ($M = 7.37$, $SD = 3.12$) reported significantly less task difficulty than ADHD participants in the CPT Depletion group ($M = 10.00$, $SD = 2.57$; $\Delta M = -4.52$, $SE = 1.19$, $t = 3.79$, $p < .001$, $\eta^2 = .12$) and ADHD participants in the AR Non-Depletion group ($M = 9.56$, $SD = 3.30$; $\Delta M = -2.19$, $SE = .84$, $t = 2.61$, $p = .012$, $\eta^2 = .06$).

Supplementary Analyses

Selected ANOVAs and simple contrasts were analyzed for the Gambling Task (GT) and Vocabulary in terms of fatigue and task difficulty. REQ scores 11 to 20 (GT) and 21 to 30 (Vocabulary) were used in analysis. The results for the GT were consistent with those obtained for the Handgrip task and with experimental hypotheses. Consistent with Hypothesis 1, for Non-ADHD participants, there were trends for CPT Depletion participants to report both more fatigue and greater task difficulty on the GT than did AR Non-Depletion participants. Consistent with Hypothesis 2, ADHD participants reported greater fatigue ($\Delta M = .61$, $t(104) = 1.93$, $p = .029$ (1-tailed), $\eta^2 = .03$) and task difficulty ($\Delta M = 1.19$, $t(104) = 1.95$, $p = .027$ (1-tailed), $\eta^2 = .04$) on the GT than did Non-ADHD participants. Consistent with Hypothesis 3, ADHD/CPT participants (most depleted) reported greater fatigue scores ($\Delta M = 1.04$, $t(104) = 2.31$, $p = .025$ (1-tailed), $\eta^2 = .05$) and task difficulty scores ($\Delta M = 2.82$, $t(104) = 3.25$, $p = .001$ (1-tailed), $\eta^2 = .09$) on the GT than Non-ADHD/AR participants (least depleted). There were no significant group differences in manipulation check variables on the Vocabulary task.

Relationships between variables were examined using correlational analyses. Although interesting, extensive analyses regarding numerous experimental variables were outside of the scope of the current study. Analyses were limited to the relationship between the three dependent variables (HG-Net, GT-AB, and Vocabulary), demographic and experimental variables. Scores on the Handgrip task, Gambling Task, and Vocabulary were uncorrelated, with the exception that GT-AB correlated negatively with Vocabulary ($r = -.24$, $p = .012$). Individuals who performed better on the Gambling Task (decreased disadvantageous responding/GT-AB scores) had higher Vocabulary scores.

As seen in Table 1, demographic variables exhibited few significant correlations with the dependent variables. Only gender correlated with HG-Net scores: females exhibited higher scores (less ego depletion) than males. Age, years of education, university grades (GPA) all exhibited significant negative correlations with GT-AB scores (i.e., negative GT-AB scores indicate better performance in terms of decreased disadvantageous responding). Greater age, more years of education, and higher GPA all correlated with better GT performance. Similarly, age, years of education, and GPA all correlated with better performance on Vocabulary (i.e., higher raw scores).

Similarly, none of the psychological or personality measures correlated with HG-Net scores. Based on previous research, it was hypothesized that ADHD symptom measures (WURS, ABC-C, and ABC-A) and the SCS would be correlated negatively with the HG-Net scores (i.e., higher self-reported self-control difficulties correlated with decreased handgrip stamina/greater ego depletion). However, the psychological measures did correlate with GT performance. ADHD symptom measures (WURS, ABC-C, and ABC-A) and the SCS correlated positively with GT-AB scores. That is, self-reported difficulty with self-control correlated with failure to decrease disadvantageous

Table 1

Correlations Between Dependent Measures and Demographic, Psychobehavioural, and Experimental Variables for ADHD and Non-ADHD Participants

Variable	HG-Net	GT-AB	Vocabulary
Demographic			
Age (Years)	.03	-.27**	.39**
Gender	.25*	.06	.11
Education (Years)	-.17	-.30**	.38**
High School Grades	-.06	-.11	.07
G.P.A.	-.03	-.20*	.24*
Academic Satisfaction	.04	-.07	.05
Psychobehavioural			
WURS (Total)	.08	.40**	-.17
ABC-C (Total)	.07	.28**	-.10
ABC-A (Total)	.09	.19*	-.11
SCS (Total)	.02	.31**	-.16
CES-D (Total)	.10	.16	-.25*
Physical Exercise	.22*	.12	-.09
Caffeine	-.09	-.01	.13
Alcohol	-.02	.28**	-.06
Smoking	-.11	.23*	-.21*

Notes. * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed). Gender = (1 = *male*, 2 = *female*).G.P.A. = Grade Point Average. Academic Satisfaction = satisfaction with school performance (1 poor, 7 high). WURS = Wender Utah Rating Scale (Total score). ABC-C = Childhood Attention Behavior Checklist. ABC-A = Adulthood Attention Behavior Checklist. SCS = Self-Control Scale. CES-D = Centre for Epidemiological Studies Depression Scale. Physical Exercise = engaged in regular physical exercise (0 = *no*, 1 = *yes*). Caffeine = caffeine intake. Alcohol = alcohol intake. Smoking = smoking intake. HG-Net = net Handgrip task score. GT-AB = net Gambling Task AB score. Vocabulary = WAIS-III Vocabulary raw score.

responding on the GT. Depression (CES-D) did not significantly correlate with GT-AB scores, but did exhibit a trend in the hypothesized direction (i.e., greater depression, more disadvantageous responding).

Consistent with experimental hypotheses, psychological and personality measures generally did not correlate with Vocabulary scores. Vocabulary scores were hypothesized to be relatively immune from depletion effects and self-control difficulties. The self-report self-control measures exhibited non-significant negative correlation trends with Vocabulary scores. In contrast, depression (CES-D) correlated negatively with Vocabulary scores (i.e., greater depression, lower verbal performance).

Physical exercise correlated positively with HG-Net score. Participants who reported in interview/background questionnaires that they were engaged in regular physical exercise exhibited handgrip stamina/less ego depletion.

In terms of other behavioural measures, self-reported alcohol intake (average drinks per day) correlated with GT-AB scores. Higher alcohol intake correlated with poorer GT performance (i.e., failure to decrease disadvantageous responding). Smoking (packs per day) also correlated with poorer GT-AB scores and with poorer Vocabulary performance (i.e., lower verbal scores). Caffeine intake (cups per day) did not correlate with any of the dependent measures.

DISCUSSION

One of main goals of the current study was to extend previous research on the strength model of volitional self-control (Baumeister, 2000, 2001; Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998) into the clinical realm by including a sample from a population that is theoretically and diagnostically defined as having self-control difficulties: individuals with symptoms of Attention Deficit Hyperactivity Disorder (ADHD). Based on reviews of the research literature on ADHD and self-control, it was hypothesized that ADHD participants who completed a resource depletion protocol (the Conner's CPT) would exhibit the poorest performance on volitional self-control tasks (i.e., the most self-control resource/ego depletion) compared to other participant groups: ADHD individuals in a non-depletion protocol (Arithmetic; AR) and Non-ADHD individuals in depletion and non-depletion protocols. Conversely, it was also hypothesized that Non-ADHD participants who completed the non-depletion protocol (AR) would exhibit the best performance on volitional self-control tasks (i.e., the least ego depletion).

Summary of the Results

The current section summarizes the key results for Non-ADHD and ADHD participants in relation to the experimental hypotheses. Subsequent sections comment on participants, tasks, and measures of the current study; strengths and weaknesses of the current study; and directions for future research.

Non-ADHD Participants

The results of the study provided partial support for the experimental hypotheses. There was some evidence to support the main Protocol effect in that Non-ADHD/CPT participants performed more poorly than Non-ADHD/AR participants on the Handgrip task (HG): CPT Depletion participants exhibited lower HG-Net scores suggestive of decreased stamina and persistence (i.e., ego depletion). These results were consistent with previous self-control research (Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998). Moreover, Non-ADHD/CPT participants (least depleted) reported higher levels of post-task fatigue than did Non-ADHD/AR participants (most depleted), and there was a trend for Non-ADHD/CPT participants to report higher levels of task difficulty (on the CPT) than Non-ADHD/AR participants. Both increased fatigue and higher perceived task difficulty were consistent with the self-control resource depletion model. Also consistent with previous research was the finding that Non-ADHD/CPT and Non-ADHD/AR participants did not differ significantly on self-reported mood and arousal after the protocol tasks, or in their self-reported task effort/motivation (Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998). Taken together, HG-Net results for Non-ADHD participants were consistent with previous self-control research and the experimental hypotheses.

In addition to HG performance, it was hypothesized that the resource depletion effect would carry-over and impair Gambling Task (GT) performance. Specifically, it was hypothesized that participants in the CPT Depletion condition, compared to AR Non-Depletion participants, would perform more poorly on the GT, as measured by GT-AB scores (measuring change in disadvantageous responding). Contrary to experimental hypotheses, there was no evidence of better GT performance (i.e., lower GT-AB scores) for AR Non-Depletion participants compared to CPT Depletion participants. In contrast, only a significant Non-ADHD versus ADHD group difference was found: all Non-ADHD participants performed well on the GT and decreased disadvantageous responding over the course of the task. It was also hypothesized that CPT Depletion participants might report more fatigue and task difficulty on the GT than AR Non-Depletion participants. There was some support for these latter hypotheses, as Non-ADHD participants in CPT Depletion condition reported more fatigue and task difficulty than Non-ADHD participants in the AR Non-Depletion condition.

Finally, it was hypothesized that performance on a task of crystallized verbal intellectual functioning, as measured by the Vocabulary task (raw scores), would be relatively immune from self-control resource depletion effects. In other words, it was hypothesized that CPT Depletion and AR Non-Depletion participants would have relatively equal Vocabulary scores. Consistent, with this hypothesis, there was no evidence of significant group differences in verbal scores for Non-ADHD participants.

ADHD Participants

It was hypothesized that the resource depletion effect would be replicated in ADHD participants *and* that the results would be even more pronounced—in that ADHD participants would exhibit the poorest performance on volitional self-control measures. Contrary to hypotheses, there was no evidence of a resource/ego depletion effect on the Handgrip task. Both ADHD/CPT and ADHD/AR participants exhibited relatively equal HG-Net (stamina and persistence) scores. In terms of fatigue and perceived task difficulty, there was only a trend for ADHD/CPT participants to report higher fatigue scores. Finally, as expected, the two groups (ADHD/CPT and ADHD/AR) did not differ on mood, arousal, or task effort-motivation.

On the Gambling Task (GT), there was little evidence of resource depletion. Both ADHD/CPT and ADHD/AR participant groups obtained relatively equal GT-AB scores; however, as hypothesized, the ADHD/CPT group did perform more poorly (i.e., the GT-AB scores of the ADHD/AR group were below zero, suggestive of decreased disadvantageous responding, whereas the GT-AB scores of the ADHD/CPT group did not differ from zero). In addition, ADHD/CPT participants reported higher perceived task difficulty on the GT than did ADHD/AR participants.

On the Vocabulary task, consistent with experimental hypotheses, there were no differences between the ADHD/CPT and ADHD/AR groups on verbal performance. Similarly, there were no differences in fatigue or perceived task difficulty.

Comparison of ADHD and Non-ADHD Participants

As noted, it was hypothesized the ADHD/CPT participants (most depleted) would exhibit the poorest performance on volitional self-control measures and, conversely, Non-ADHD/AR participants (least depleted) would exhibit the best performance. These hypotheses were not supported on the Handgrip task (HG), with the exception (1) that Non-ADHD/AR participants had the highest HG-Net scores (i.e., the least resource depletion), the lowest fatigue scores, and perceived task difficulty scores; and (2) that ADHD/CPT participants had the highest HG fatigue and perceived task difficulty scores.

On the Gambling Task (GT), there was some support for the hypotheses: (1) ADHD/CPT participants had the highest GT-AB scores (i.e., most difficulty decreasing disadvantageous responding), the highest GT perceived task difficulty, and the most fatigue; and (2) the Non-ADHD/AR group reported the least fatigue on the GT.

Results for the Vocabulary test supported the hypothesis that the test would be immune from resource depletion effects. Vocabulary performance did not differ between groups.

Interpretation of the Results

Taken together, the current study provides some support for the strength of volitional self-control model. Consistent with previous research, "normal" Non-ADHD participants showed some evidence of resource depletion on the Handgrip (HG) task. However, with the exception of higher fatigue and perceived task difficulty, the depletion effect did not carry-over as expected to the Gambling Task (GT). Failure to find depletion carry-over to the GT can imply either that the depletion effect was weak (i.e., individuals recovered quickly from resource depletion after the CPT) or that the GT was too easy a task for "normal" individuals (i.e., without self-control impairment).

Volitional Self-Control

The strength model of volitional self-control is about conscious, controlled, executive-type effort. In previous studies of the model, cited in the introduction, participants applied conscious effort in a variety of ways: behaving in ways counter to their beliefs, trying not to think about a white bear, trying to inhibit their emotional reactions, monitoring their diet, and making decisions. In the current study, participants in the depletion condition worked on the Conners' CPT. It could be argued that the task demands of the CPT—quickly pressing or not pressing a computer spacebar—are relatively easy, more automatic, and require less volitional effort than the tasks used in previous research.

The Murtagh and Todd (2004) study, which used the computerized Stroop Color and Word Test (Stroop), also tapped these more basic neuropsychological processes. That study failed to find resource depletion on the Handgrip (HG) task in participants who had completed the Stroop. In contrast, the current study (and the pilot study) did find some evidence of depletion on the HG in participants who had completed the CPT. However, the effect did not carry-over to the Gambling Task (GT), and, surprisingly, the depletion effect was not evident in ADHD participants. In the current study, the CPT may have tapped volitional resources only to a minor extent. Moreover, different resources may have been tapped in ADHD and Non-ADHD participants (e.g., volition in Non-ADHD, attention in ADHD).

It is possible, based on the current results and those of the Murtagh and Todd (2004) study, that computerized tasks are less depleting because they might be perceived as "computer games." Although these tasks may be difficult, frustrating, and tiring, they may be viewed as more pleasurable or less "real" than everyday, volitional tasks. As a result, they may not drain volitional resources the same way or as much as the tasks used in previous self-control research.

Situational and Demand Characteristics

Other possible factors responsible for the lower than expected depletion effects in the current study are situational and demand characteristics. Hallowell and Ratey (1994), for example, suggest that situational factors in psychological assessment settings impact on the performance of individuals with ADHD symptoms: individuals often do better than expected in neuropsychological testing situations likely because these situations parallel situations that, in general, attenuate ADHD symptoms (e.g., working in a novel situation, working on interesting tasks, and having one-on-one attention). Murtagh and Todd (2004) suggested that demand characteristics in their study may have interfered with expected depletion results when they observed that participants attempted to increase effort on tasks more than expected (e.g., increased stamina on HG trial 2).[31]

In previous ego depletion studies (e.g., Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998), participants (1) were usually left alone to work on tasks and/or (2) worked on ostensibly unrelated tasks in different rooms with different examiners (e.g., tasted food in one room, worked on anagrams in another room). In the current study and in the Murtagh and Todd (2004) Stroop study, an experimenter was present in the room throughout the experiment and conducted all of the experimental tasks with the participant. In the current study, which showed more evidence of depletion than the Murtagh and Todd study, the experimenters maximized their distance away from the participants (e.g., working on paperwork in the far corner of the room). Nevertheless, having an observer present could have had an effect on volitional self-control and/or volitional resources. Having an observer present could have increased participants' motivation on tasks. Moreover, having an observer present could have caused participants to use fewer volitional resources because the presence of the observer could have kept them on task (as opposed to having to rely on their own volitional resources to do so).[32]

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[31] In previous self-control studies (e.g., (Baumeister, Bratslavsky et al., 1998; Muraven & Baumeister, 2000; Muraven et al., 1999; Muraven et al., 1998), participants were not informed of how well they did on the HG (how long they spent holding it) on either trial 1 or 2. This same protocol was followed in the current study. It is not clear, however, that this protocol was used in the Murtagh and Todd (2004) study.

[32] This may parallel the findings of Shoda and colleagues (1990) on the delay of gratification in children studies. As noted, the researchers conducted longitudinal follow-ups on some of the study participants in adolescence and found that the participants who had to come up with their own self-control strategies in an experimental condition were the ones who exhibited the best functioning in later years (e.g., higher SAT scores). In the context of the volitional resource model, having had to work on one's own contributed to greater self-control strength over time.

Over-Depletion, Inattention, or Conservation in ADHD

The finding that ADHD participants did not exhibit greater resource depletion than Non-ADHD participants was unexpected. Failure of ADHD participants to show resource depletion in the hypothesized manner may be attributable to several interrelated factors: over-depletion, inattention, and resource conservation.

One possibility is that ADHD participants were already *over-depleted* at the onset of the study; therefore, they could not deplete any further—which made them appear immune to depletion effects. Evidence for the hypothesis that ADHD participants were over-depleted (or pre-depleted) at the onset comes from the finding that ADHD participants reported higher levels of fatigue and perceived difficulty on tasks, more negative mood and higher levels of depression, higher levels of arousal and irritability, poorer sleep and stress-management skills, and greater self-control behavioural difficulties (i.e., higher SCS scores, higher use of caffeine, alcohol, and smoking). Examination of baseline handgrip scores before experimental protocols (Time 1 scores) suggested no significant difference between groups: ADHD did not appear to be more depleted (i.e., have less stamina) than Non-ADHD participants at the start of the study. Conversely, if they were more depleted at the onset of the study, this was not reflected in their baseline handgrip scores.

Another possibility is that there is something inherent to ADHD that interacted with the research protocol and thus attenuated depletion effects in ADHD participants. As noted, Barkley's (1997) ADHD model posits the central deficit in the disorder is a disinhibitory self-control deficit (which then impairs other functions, including attention). Others postulate that *inattention* is the central deficit in ADHD (that then impairs inhibition; Brown, 1995a, 1995b). Irrespective of the underlying theoretical model, attention is impaired in ADHD participants. Consistent with the diagnosis, ADHD participants exhibited evidence of attention impairment on the CPT in the current study. ADHD participants also made more errors on the Arithmetic task. One possibility is that the attention impairment confounded the results. For example, if participants were inattentive on the CPT, they would likely (1) *exhibit poorer CPT performance* (e.g., increased omission errors, commission errors, and overall impairment index) and (2) *use less volitional self-control resources* (i.e., if one is not attending to the task, one may not be depleted by the task). Using less volitional resources could then lead to "normal" or non-depleted performance on a subsequent volitional self-control task such as the Handgrip (HG) task.

Another possibility is that the AR Non-Depletion task was ego-depleting for ADHD participants. While the task does rely primarily on the application of well-learned problem-solving rules, it also does require participants to sit and attend. Individuals with self-control difficulties might have to utilize more self-control resources than individuals without self-control difficulties in order to perform the task. Resource depletion could be expected especially if the individuals found the task not enjoyable or difficult. As reported in the Results section, there was evidence of greater fatigue and perceived task difficulty for ADHD participants than for Non-ADHD participants on the arithmetic task.

At first glance, the finding that ADHD participants did not show the expected depletion pattern seems to imply that the strength of volitional self-control model applies *only* to normal, non-clinical participants. Another interpretation is that a modified resource model—such as the *resource conservation* model, noted in the introduction—may be more accurate for participants with self-control difficulties (Baumeister, 2001). In the resource conservation model, individuals who are resource-depleted will conserve volitional resources in order to prevent further depletion. As a result, (1) they may apply less volitional self-control effort into tasks than non-depleted individuals, and (2) they may show less evidence of resource depletion than non-depleted individuals. Results of the Time 2 Handgrip scores, which were consistent with the overall HG-Net results, suggested that ADHD participants had equal amounts of stamina in both the AR Non-Depletion and CPT Depletion protocols. These results would support an inefficient conservation or "failure to conserve" hypothesis for ADHD individuals.

Summary

The results of the current study can be interpreted with respect to the nature of the volitional tasks used in the current study, observer effects, and demand characteristics. The less-than-expected resource depletion in ADHD participants could be interpreted in terms of demand characteristics, inattention, over-depletion, and the conservation model. In the context of the conservation model, a key finding in the current study might be that individuals with ADHD, compared to Non-ADHD individuals, differ in the exertion that they apply to volitional self-control tasks. Where Non-ADHD individuals might conserve energy (to prevent depletion), ADHD individuals may fail to conserve. This potentially inefficient use of resources may then make them more vulnerable to failure on subsequent self-control tasks.

Design Issues and Theoretical Implications

The current section addresses design issues in terms of study participants, measures and instruments, and protocol design for the current study. Where appropriate, theoretical implications and recommendations for future research are addressed.

Participants

In the current study, considerable effort went into recruiting individuals with significant ADHD symptoms and matching the ADHD participants with Non-ADHD individuals in terms of age, gender, and educational faculty. Matching participants on years of education was not done; however, the groups were equivalent in years of education as well. Although the ADHD symptom group was a not a "pure" diagnostic or clinical group (i.e., with all of the participants having clear-cut diagnoses of ADHD), the ADHD group represented a valid entity that is consistent with hypothesized ADHD characteristics. Compared to Non-ADHD participants, the ADHD participants reported longstanding and significant numbers of ADHD symptoms and self-control difficulties; reported higher levels of ADHD symptoms and self-control difficulties; reported poorer academic performance and poorer psychological functioning; exhibited poorer performance on CPT and AR protocol measures, suggestive of inattention and inconsistency; exhibited poorer performance on the Gambling Task (GT), a task believed to be sensitive to difficulties with impulse control and decision making.

The psychological functioning difficulties reported by the ADHD group participants were consistent with other findings from the research literature. As noted in the introductory chapters, higher incidence of depression, poorer performance on neuropsychological tests, and lower academic functioning are characteristic of university and college students with confirmed ADHD and of students self-reporting ADHD symptoms (Dooling-Litfin, 1997; Dooling-Litfin & Rosen, 1997; Griffin, 1999; Heiligenstein & Keeling, 1995; Konyk et al., 1999; Presnell, 2000; Richards et al., 1999; Turnock et al., 1998). In contrast to some of the previous research (e.g., comparing participants on self-reported ADHD symptoms; Konyk et al., 1999; Perretta & Beninger, 2004), the ADHD participants in the current reported high levels of symptoms and associated psychosocial difficulties (e.g., depression).

Inclusion of Hyperactive-Impulsive and Inattentive Subtypes

The current study included a broad cross-section of individuals with reported ADHD symptoms (i.e., Inattentive type, Hyperactive-Impulsive type, Combined type, and NOS). As previously noted, the rationale for this broad group was based on several factors such as consistency with previous research, current DSM-IV classification criteria, symptom overlap, and logistical issues. Nevertheless, it could be argued that the study should have limited its focus to individuals with significant hyperactive-impulsive ADHD symptoms alone – because this is the group defined by Barkley's (1997) model of behavioural disinhibition and self-control difficulty. It is possible that primarily inattentive and primarily hyperactive-impulsive responded differently to the protocol and dependent tasks used in the current study. Given limitations in sample size and availability of detailed background/diagnostic information, comparisons between ADHD Inattentive type and ADHD Hyperactive-Impulsive/Combined were not feasible in the current study. However, preliminary post hoc exploratory analyses, comparing ADHD individuals with a higher number of hyperactive-impulsive symptoms (Hyperactive group) to those with fewer hyperactive-impulsive symptoms (Inattentive group), suggested the possibility that groups differed in task performance. For example, it appeared that the Hyperactive group may have found the AR Non-Depletion protocol more depleting than the Inattentive group. The Hyperactive group is more consistent with Barkley's (1997) model of behavioural disinhibition. Moreover, the Hyperactive group appeared to have lower Time 1 and Time 2 Handgrip scores – results that are consistent with the above-noted over-depletion model. These results are reported with caution and need to be explored in future research.

Measures and Instruments

Handgrip Task

The Handgrip (HG) task was sensitive to hypothetical self-control depletion effects in the pilot study and for Non-ADHD participants in the main study. There was no evidence of a depletion effect on HG-Net scores for ADHD participants. ADHD and Non-ADHD participants did not differ on initial (Trial 1) HG scores; nor did ADHD participants exhibit more variability on handgrip scores than Non-ADHD participants.

The HG task has been used in previous self-control studies and has generally been shown to be sensitive to hypothesized resource depletion effects (Baumeister, Bratslavsky et al., 1998; Muraven et al., 1998, 1999). Previous HG research has been with normal university and college students. In the current study and in the pilot study, normal (Non-ADHD) participants exhibited the expected depletion pattern (lower HG-Net scores) after completing the CPT. In contrast, students with self-control difficulties (i.e., ADHD symptoms) did not exhibit the expected results. Some reasons for the failure of the HG to reveal depletion in ADHD participants were addressed in the above section.

There is some research evidence to suggest that HG performance may be affected by factors other than resource depletion. These factors include motivation effects, task variability, gender, physical exercise, and handedness. In their study, Murtagh and Todd (2004) found that HG scores correlated with motivation. Participants in the study were motivated to do well on the task. This motivation may have been exacerbated by participants being aware of their performance on the task (i.e., being aware of their Trial 1 scores they were motivated to try harder on Trial 2). Motivation effects were not observed in the current study. However, motivation on the HG was not assessed directly.

The HG task yields high standard deviations. In the current study, Time 1 and

Time 2 scores had standard deviations of approximately 40 seconds, and the calculated HG-Net scores had standard deviations of approximately 20 seconds. Even higher standard deviations in HG scores have been reported in other studies (e.g., 90 sec; Murtagh & Todd, 2004). The high variability of HG scores may limit the task's reliability and its sensitivity to depletion effects. These difficulties may be exacerbated in certain populations such as females (i.e., possible gender differences; Murtagh & Todd, 2004), individuals experiencing stress (e.g., university students during exams; Muraven et al., 1999), and individuals experiencing self-control difficulties (e.g., ADHD). In the current study, there was some evidence that female participants exhibited higher HG-Net scores (less ego depletion) than male participants. Post hoc examination of the data suggested that the apparent gender difference was due to males having a higher Time 1 and Time 2 HG scores. Because males held the HG longer than females (e.g., 60 sec as opposed to 20 sec) they exhibited greater apparent losses – because of the greater possible range. For example, if both groups decreased stamina by 50 percent, males would have HG-Net scores of –30 sec and females would have net HG-Net scores of –10 sec.[33]

In the current study, HG-Net scores also correlated with self-reported physical exercise (e.g., walking, jogging). Participants who reported being engaged in some form of regular physical exercise exhibited higher HG-Net scores (i.e., less ego depletion) than

[33] It is also possible that gender differences interacted with ADHD symptomatology, further complicating the results. As noted in the introduction, boys outnumber girls in ADHD symptoms, and boys are more likely to have hyperactive-impulsive symptoms. In the current study and previous research, there appear to be relatively equal numbers of males and females with ADHD symptoms. Both males and females reported relatively equal childhood symptoms of inattention and hyperactivity-impulsivity. However, as noted above, ADHD inattentive and ADHD hyperactive-impulsive participants may have performed differently on tasks. The combination of gender (e.g., females having lower baseline stamina) and ADHD (e.g., hyperactive-impulsive ADHD having lower baseline stamina) on HG scores highlights the need for future research in this area.

non-exercising participants. This finding, if replicated, suggests that strength and stamina benefits that one may obtain from regular exercise may impact on HG performance.

A final factor related to the above-mentioned ones is handedness. While participants in the current study were well matched in terms of age, gender, and education, they were not matched in terms of handedness. There were more individuals self-described as left-handed in the ADHD group and more indivduals self-described as ambidextrous in the Non-ADHD group. Individuals reported their handedness on a background questionnaire in the study and used their self-reported non-dominant hand on the HG task. Individuals self-described as left-handed or ambidextrous may have mixed lateralization (e.g., writing with left hand, but performing most physical activities with right hand; Lezak, 1995) and their self-reported non-dominant hand may in fact be stronger. Participants using their stronger hands might exhibit different depletion patterns (e.g., more apparent depletion) on the HG than participants using their weaker hands. It is not clear how much, if at all, handedness affected the results on the HG task.

Gambling Task

It was hypothesized that the Gambling Task (GT; Bechara et al., 1994) would be sensitive to both protocol effects and group effects—that participants in the CPT Depletion condition would do more poorly on the GT than participants in the AR Non-Depletion condition, that ADHD participants would do more poorly on the GT than Non-ADHD participants, and that ADHD/CPT participants would have the poorest GT performance. Only the group effect was clearly supported: ADHD participants performed more poorly than Non-ADHD participants. As noted, there was some evidence of a depletion effect in that ADHD/CPT participants (most depleted) reported more perceived task difficulty and fatigue on the GT than Non-ADHD/AR participants (least depleted).

The finding that the ADHD/CPT participants perceived the task as more difficult (compared to the other groups) is consistent with the resource depletion hypothesis. The finding that both ADHD groups did poorly suggests that the GT was more difficult for ADHD participants than Non-ADHD participants. The finding that both Non-ADHD groups did well on the task suggests that it was perhaps too easy for Non-ADHD participants and therefore insensitive to depletion effects.

The finding that Non-ADHD participants and "high functioning" ADHD participants both did well on the GT in the Perretta and Beninger (2004) study suggests that higher functioning individuals (compared to those with neuropsychological or self-control difficulties) find the task relatively easy. The Perretta and Beninger study found no difference on GT performance between ADHD and Non-ADHD participants. In contrast, the current study found that ADHD participants had higher GT-AB scores than Non-ADHD participants: they had more difficulty decreasing disadvantageous responding. The ADHD participants in the Perreta and Beninger study were "high functioning" university students who scored higher (compared to other students) on a self-report checklist measure of ADHD. The ADHD group did not differ from the control group on academic performance or depression. In contrast, the ADHD group in the current study scored in the clinical range on ADHD symptom measures, had lower GPA scores than Non-ADHD participants, and had higher levels of depression than Non-ADHD participants.[34] Compared to the Perreta and Beninger study, the ADHD participants in the current study were more impaired and likely more representative of a

[34] As noted, CES-D depression scores did not correlate significantly with GT-AB scores. CES-D depression scores exhibited significant negative correlations with Vocabulary scores, ADHD/self-control measures correlated significantly with GT-AB scores, and ADHD/self-control measures were relatively uncorrelated with Vocabulary scores. Taken together, the results suggest that in the current study self-control deficits, as opposed to depression, contributed to GT performance deficits.

true ADHD sample.

In the current study, older age, more education, higher grades, lower alcohol use, and higher intellectual functioning all correlated with better GT performance. The results support the argument that higher functioning (e.g., maturity, better school performance, higher intellectual functioning) is associated with better performance on the GT.

Vocabulary

It was hypothesized that the Vocabulary task, a measure of crystallized verbal intellectual functioning, would be relatively immune from resource depletion effects and that there would be little, if any, difference in verbal performance between ADHD and Non-ADHD participants and between CPT Depletion and AR Non-Depletion participants. The experimental results were consistent with these hypotheses.

Self-Control Scale

In the current study, scores on the Self-Control Scale (SCS; Tangney et al., 2004) correlated with symptom measures of ADHD and with symptoms of depression. Contrary to experimental hypotheses, there was no association between SCS scores and Handgrip stamina scores. However, the SCS did exhibit the hypothesized correlation with GT scores; SCS scores correlated positively with GT-AB scores, indicating that self-control difficulties were associated with difficulty decreasing disadvantageous responding.

Conners' CPT

Results of the current study suggested that the Conners' CPT could have a self-control resource/ego depletion effect in some participants. As noted, evidence suggestive of ego depletion was found in normal/Non-ADHD participants on the CPT in terms of lower HG-Net scores, higher fatigue, and greater perceived task difficulty. No evidence of depletion was seen in ADHD participants in terms of HG-Net scores after the CPT;

however, there were expected higher reports of fatigue and perceived task difficulty.

Modifications of the CPT protocol in future resource depletion research. Although the CPT protocol appears to have some usefulness in ego depletion research, some modifications may be warranted. Using as an example the letter-cancellation task paradigm (i.e., crossing out the letters *e* in a text according to certain selection criteria; Baumeister, Bratslavsky et al., 1998), the CPT protocol could be modified to strengthen the volitional component of the task. In the letter-cancellation task, participants were first trained to cross out all of the letter *e* in a text, creating a prepotent response. Participants in the resource depletion condition were then instructed to cross out the letter *e* only if *e* was the only vowel in the word. A similar variation could be added to the CPT protocol. A strong prepotent response could be created by having participants respond (quickly press computer spacebar) to all the letters on the CPT for a period of time (e.g., five minutes) and subsequently require participants to inhibit responding to selected letters (e.g., *X*, as in the current CPT paradigm). In theory, this variation would create a stronger prepotent response and cause more resource depletion than the current CPT paradigm.

Strengths and Limitations

Strengths of the current study include the following: (1) The study extended research on the strength model of volitional self-control into the clinical realm by including a sample from a population who have difficulties with self-control. The ADHD group appeared to be a valid sample that reported significant self-control difficulties and demonstrated impairment and/or difficulties on selected experimental tasks. (2) The ADHD symptom group was matched with control participants in terms of age, gender, educational faculty, and years of education. (3) The study utilized examiners who were blind to participants' group membership (ADHD or Non-ADHD) and experimental hypotheses. (4) The study utilized measures—such as the Conners' CPT, the Gambling Task, and the Vocabulary task—that have not been used in previous self-control research.

In terms of limitations, power and effect size were relatively low. Power was strong for some of the ADHD main and simple effects (e.g., over .80 for GT-AB, fatigue, mood, task difficulty), but relatively weak for protocol main and simple effects (e.g., .76 for fatigue; less than .40 for other protocol effects). Effect sizes (η^2) generally accounted for small amounts of the variance between variables. For example, the protocol effect on HG-Net scores for Non-ADHD participants accounted for 8% of the variance, the group main effect on GT-AB scores accounted for 9% of the variance, and the contrast between ADHD/CPT and Non-ADHD/AR participants accounted for 12%.

Other limitations were related to the experimental design: (1) Medication compliance was not enforced. When participants were booked for the study, they were asked not take stimulant/ADHD medication, if possible, prior to testing. However, compliance was not assessed at time of testing (in part to minimize experimenter bias).[35] (2) Due to a clerical error, Handgrip (HG) task performance and manipulation checks were not assessed by post-experimental questionnaire. (3) With the exception of the BMIS, post-experimental/manipulation check questionnaires were administered at the end of the experiment, as opposed to at the completion of each subtest (e.g., Handgrip test, Gambling Task, Vocabulary). Participants provided retrospective data on manipulation variables. This may have introduced some bias into participants' responses. (4) Potentially important variables such as physical exercise, handedness, caffeine use, alcohol abuse, and smoking were assessed by brief one-item measures in the background

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[35] It is unclear how medication would have influenced the results. Theoretically, based on the current results, ADHD individuals taking medication would have performed better (more normal) on the CPT task and possibly shown more ego depletion (i.e., more similar to Non-ADHD individuals).

questionnaire. More detailed information (e.g., consistent with health surveys) would have been helpful. (5) Finally, as noted above, the ADHD sample, although consistent with previous research was a mixed sample (i.e., including inattentive and hyperactive-impulsive subtypes). Ideally, only participants with the hyperactive-impulsive subtype would have been included in the study.

Areas of Further Study

The current study explored the utility of the strength model in the clinical realm by looking at individuals with ADHD and by including previously unused protocol and assessment tasks. The study provided an important first step in examining the utility of the model in clinical populations. The experimental results were both consistent with aspects of previous self-control strength research (e.g., depletion effects in normal university students on HG, but no depletion effect on GT and verbal functioning) and also unexpected (e.g., lack of resource depletion in university students with ADHD symptoms, possible support for a resource conservation model). Taken together, the results suggest additional research questions and variables to study in future research. Some of these research questions include the following:

(1) What is the best control group to use in clinical research on ADHD and the resource depletion model? What other populations should be included in research? The current study results indicated different patterns of results for ADHD and Non-ADHD participants, with the Non-ADHD results being consistent with those of previous research (i.e., resource/ego depletion model) and the ADHD results being suggestive of another model (i.e., resource conservation model). The results suggest that "normal" controls may not be a sufficient comparison group. In future tests of the model with ADHD participants, comparison groups that share some overlapping characteristics should be

included. Examples of suitable comparison groups include: individuals with depression (without history of self-control difficulties), individuals with substance-abuse issues (who may be expected to exhibit some self-control difficulties and perhaps difficulties on the GT), and participants with frontal lobe injuries (who would exhibit executive functioning and self-control difficulties that might be more severe than those affecting individuals with ADHD). These groups would be expected to have both similar and different response patterns, test performance scores, and resource depletion/conservation effects.

As noted above, it is also important to examine issues related to ADHD subtypes and gender. Future studies should examine relatively pure samples of hyperactive-impulsive and inattentive subtypes, for example, to see if the two groups exhibit different task performance and depletion patterns. Similarly, differences in gender are worth further study, for example to see if the tasks and measures used exhibit different patterns in males and females. Finally, the link between gender and ADHD subtypes and the possible interaction on test performance and depletion needs to be explored.

(2) What design variations could be made in replication of the current study? If replicated, the current study could be modified in several ways. First, two similar computer-type tasks might be used, as in the Murtagh and Todd (2004) study. The depletion condition could consist of the CPT and a parallel task (e.g., bar pressing to all stimuli, ostensibly as a test of reaction time)—to eliminate possible arousal or motivational effects that might exist between the CPT and AR tasks. Moreover, as noted above, the CPT protocol could be modified to strengthen the prepotent responses by having all participants initially practice by bar pressing to all of the letters.

Another variation could be to have the examiner be outside of the room—to eliminate possible observer/situational effects (e.g., increased motivation) or demand characteristics. Instructions could be written and/or audio taped for participants and participants could be observed by video or through a one-way mirror. Distractible behaviours could be coded (e.g., looking around the room, looking away from the task) and could prove useful information (e.g., correlation between distractible behaviours and task performance, questionnaire data, and depletion measures).

(3) What other tasks and variables might be important? As noted, results suggested important effects from variables such as *physical exercise* (e.g., being engaged in regular exercise correlating with less HG depletion), *alcohol intake* (e.g., higher alcohol use correlating with poorer GT performance), *intellectual functioning* (e.g., higher academic grades and vocabulary correlating with better GT performance), and *fatigue* (e.g., higher fatigue levels being reported after depletion tasks).

In addition, it would important and interesting to include more *real-life* type tasks in the study of ADHD and self-control/depletion effects. Lezak (1995) states that real-life tasks (e.g., navigating one's way through a building, organizing work activities) may be more sensitive to deficits associated in frontal lobe/executive functioning impairment. As noted previously, individuals with ADHD and frontal lobe executive functioning deficits often do well on cognitive tasks and testing situations (Hallowell & Ratey, 1994). In the current study, one of the ADHD participants stated, "I can do well on [assessment] tests like this, but my problem is more with real life—that's where I have trouble organizing my behaviour and staying focused." The study on depletion and alcohol use by Muraven and colleagues (2002) is one example of a real life application and test of the model.

Finally, the CPT could also serve as a dependent variable. If the task uses volitional resources and leads to depletion, the task should also be sensitive to depletion effects. Protocols from previous research (e.g., having participants make decisions, eat radishes over chocolates) could be tested to see if they impair CPT performance.

(4) Specific tests of other depletion should be conducted. The study results suggested that an over-depletion model or resource conservation model might better explain the results found for ADHD participants. These models should be further investigated, perhaps through studies that can manipulate depletion levels. Examples include a sleep deprivation study that creates depletion or a study that assesses/ manipulates stress levels (e.g., testing students during exams; Muraven et al, 1999). With ADHD individuals, the inattention hypothesis is also worthy of study—to see if inattention (e.g., observed distractibility) attenuates depletion effects. For example, participants who are distracted by extraneous stimuli might show less depletion effects *or* more depletion effects (e.g., due to increased cognitive load; Murtagh & Todd, 2004).

Conclusions and Clinical Implications

As noted in the introduction, self-control is a key human strength and ability that is associated with numerous indicators of psychological, behavioural, and social well-being. The volitional models of resource strength, depletion, and conservation posited by Baumeister, Muraven, and colleagues offer interesting and important ways of studying, conceptualizing, and understanding self-control and executive functioning. Until recently, research on these models has been limited to the study of normal individuals. The current study aimed to extend the models into the clinical realm by including a sample from a population with executive and self-control difficulties—individuals with ADHD. The study incorporated neuropsychological theories of executive functioning (e.g., somatic marker hypothesis) and ADHD theory (e.g., behavioural disinhibition) and used measures previously not used in research on the strength/conservation model (e.g., CPT, Gambling Task). The study results were both expected and unexpected and offer new insights and implications for research and clinical practice.

A key implication of this study is that more research is needed on the self-control strength model before it can be applied clinically. Had the study shown the hypothesized depletion effects, with the "most depleted" ADHD/CPT group doing poorly on dependent measures, then the depletion model design could have had potential in the assessment of disorders like ADHD. For example, a strong depletion effect could have been diagnostic of ADHD impairment. Based on the current study, the opposite seems to be the case: Normal participants will demonstrate a depletion effect whereas individuals with self-control difficulties (i.e., ADHD) will not display a depletion effect.

The results could be interpreted in terms of a resource conservation model. According to the model and the current results, individuals who are resource-depleted will (1) conserve volitional self-control resources and (2) may not exhibit the self-control depletion patterns found in normal or non-depleted individuals. In terms of the current study, the results suggest that individuals with ADHD may fail to conserve appropriately, leading to a reduction in ego resources, and then be at risk for greater self-control failure at a later time (especially when self-control is important). This interpretation might explain why ADHD participants in both the CPT Depletion and AR Non-Depletion protocols exhibited more difficulty, compared to Non-ADHD participants, on the Gambling Task in the current study. Helping individuals with ADHD allocate their self-control resources appropriately (i.e., knowing when to conserve resources) may represent an important treatment focus with this population.

The study results also highlight the importance of improving our understanding of ADHD and the role of gender differences in self-control/ego depletion. In terms of ADHD, the results of the study suggest that different ADHD subtypes might perform differently on self-control tasks and have different ego depletion patterns. For example, hyperactive-impulsive ADHD participants may find hypothesized non-depletion tasks such as arithmetic ego depleting. Differences in subtype performance, if they exist, might strengthen the case for Barkley's (1997) behavioural disinhibition model of self-control and further the case that hyperactive-impulsive and inattentive subtypes of ADHD represent distinct disorders. Assessment techniques based on the self-control strength and behavioural disinhibition models could be useful in distinguishing different ADHD subtypes.

The study results also suggest the importance of examining gender in self-control research. The current study results and those in previous research (e.g., Murtagh & Todd, 2004) suggest that males and females may exhibit different results self-control and ego depletion measures. For example, tasks such as the handgrip task may be less sensitive to depletion in females (e.g., because of reduced range). Researchers and clinicians need to be cognizant of gender differences when assessing and treating self-control difficulties.

Finally, as indicated in the current document, there may be an important interaction between ADHD subtypes and gender in terms of performance on self-control tasks and ego depletion. This again highlights the importance of increasing our understanding in these domains and developing proper assessment and intervention techniques.

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APPENDIX A

Participant Data

Participants were 108 students enrolled at the University of Manitoba, the University of Winnipeg, or Red River College, all of which are located in Winnipeg, Manitoba, Canada. Fifty-four of the participants reported having significant symptoms consistent with ADHD (ADHD group), and 54 were peers matched in age, gender, and educational faculty (e.g., Arts, Science, etc.; Non-ADHD group). ADHD and Non-ADHD participants were assigned to one of two experimental conditions: Arithmetic Non-Depletion or CPT Depletion. Table A1 presents the general demographic characteristics of the four participant groups.

ADHD Symptom Group

Of the 54 participants that comprised the ADHD group, 36 (66.7%) reported formal diagnoses of ADHD. The remaining 18 participants reported both childhood and ongoing symptoms suggestive of ADHD. Many of these participants reported a family history of ADHD. The participants reported being worried about their symptoms, poor academic functioning, and being in various stages of help-seeking (e.g., awaiting a psychological assessment, seeking additional information, etc.). Two participants were excluded from the ADHD group as they reported no family history and no childhood or current ADHD symptoms. Two others were excluded due to significant neuropsychological factors (e.g., severe head injury, seizure disorder).

Table A1

Demographic Characteristics of Participants

	Arithmetic		CPT	
Variable	ADHD	Non-ADHD	ADHD	Non-ADHD
Age (*M, SD*)	23.67 (4.94)	24.11 (5.81)	25.59 (6.90)	25.52 (6.61)
Gender (%)				
Male	51.9	51.9	55.6	55.6
Female	48.1	48.1	44.4	44.4
Ethnic/Cultural (%)				
White/Caucasian	77.8	59.3	63.0	66.7
Asian	18.5	25.9	14.8	22.2
East Indian/Middle East	3.7	7.4	7.4	7.4
Latin American	0.0	3.7	3.7	0.0
Aboriginal	0.0	3.7	3.7	0.0
N/A	0.0	0.0	7.4	3.7
Marital Status (%)				
Single	81.5	92.6	81.5	70.4
Common-Law	7.4	0.0	7.4	11.1
Married	7.4	3.7	11.1	18.5
Separated/Divorced	3.7	3.7	0 .0	0.0
Handedness (%)				
Right	74.1	81.5	85.2	100.0
Left	18.5	7.4	11.1	0.0
Ambidextrous	0.0	11.1	0.0	0.0
N/A	7.4	0.0	0.0	0.0

Table A1 (continued)

Variable	Arithmetic ADHD	Arithmetic Non-ADHD	CPT ADHD	CPT Non-ADHD
HS Grades (*M, SD*)	72.83 (10.81)	78.63 (8.38)	71.23 (12.26)	76.89 (8.53)
GPA (*M, SD*)	2.91 (.76)	2.95 (.80)	2.68 (.75)	3.21 (.65)
Years Education (*M, SD*)	14.26 (2.38)	14.44 (2.56)	14.31 (2.04)	14.85 (2.58)
Faculty (%)				
Arts	14.8	14.8	22.2	22.2
Business/Management	7.4	7.4	7.4	3.7
Continuing Education	0.0	0.0	0.0	3.7
Education	0.0	0.0	3.7	3.7
Engineering	0.0	0.0	3.7	3.7
Fine Arts	3.7	3.7	0.0	0.0
Graduate Studies	0.0	0.0	3.7	3.7
Human Ecology	3.7	3.7	0.0	0.0
Law	0.0	0.0	3.7	3.7
Nursing	0.0	0.0	3.7	3.7
Science	14.8	14.8	11.1	11.1
University 1	55.6	55.6	40.7	40.7

Notes. *n* = 27 per group. % = percent. ADHD = Individuals with significant symptoms of Attention Deficit Hyperactivity Disorder. CPT = Conners' Continuous Performance Test. With the exception of Age and Years Education, data is presented as percentages. Ethnic/Cultural = Ethnic/cultural background. HS Grade = High School Grade; GPA = University/ College Grade Point Average (range 0.00 to 4.50).

Table A2

Summary of ADHD Group Background Questionnaire Responses

Item	Percent
Age When Diagnosed With ADHD	
Childhood	33.3
Adolescence	8.3
Adulthood	36.1
University	13.9
DK/Unsure	8.3
Who Diagnosed ADHD	
Doctor	16.7
Psychiatrist	25.0
Psychologist	30.6
Other	5.6
DK/Unsure	25.0
Who Initiated ADHD Testing/Assessment	
Parents	33.4
Self	38.9
School	19.5
Psychologist	2.8
Psychiatrist	2.8
Friend	2.8
Counsellor	2.8
DK/Unsure	13.9
Components of ADHD Assessment	
Interviews	69.4
Questionnaires	55.6
Psychological Testing	52.8
Review of School Records	38.9
Full Assessment (i.e., tests, interviews)	36.1
DK/Unsure	19.4
ADHD Type & Other Difficulties	
ADD (Inattentive ADHD)	27.8
ADHD (Combined type)	16.7
ADHD Symptoms, ADHD-NOS	36.1
Reading Disorder	2.8
Poor Visual Memory	2.8
Learning Difficulty	5.6
DK/Unsure	33.3

Table A2 (continued)

Medication for ADHD	
Stimulant medication	30.6
Antidepressant medication	19.4
Anti-anxiety medication	2.8
None currently	47.2
Family History of ADHD	
Parent	44.4
Siblings	41.7
Other relatives	19.4
No	13.9
DK/Unsure	30.6
Impact of ADHD Diagnosis	
Better self-understanding	25.0
Feel better knowing	11.1
Able to function/work better	2.8
Something to blame	11.1
Others more understanding	2.8
Little or no impact	25.0
DK/Unsure	19.4

Notes. *n* = 36 participants reporting formal diagnosis of ADHD. Table does not include participants awaiting psychological assessment or diagnosis. Numbers represent percentages and may not tally up to 100% as several participants gave multiple responses to the questions.

Table A2 summarizes the responses of the 36 participants reporting an ADHD diagnosis. Due to incomplete data, information on participants awaiting psychological assessment or diagnosis is not reported. Approximately 50 percent of the participants were diagnosed in adulthood (i.e., adulthood or university). Forty percent reported having sought help or assessment on their own. Psychologists and psychiatrists were the most common providers of the diagnosis. Interviews, questionnaires, and psychological testing were the most common methods of assessment and diagnosis. Two-thirds reported ADHD symptoms or ADHD-NOS type diagnoses, approximately 28 percent reported ADHD Inattentive type, and nearly 17 percent reported ADHD Combined type diagnoses. Many of the participants reported family histories of ADHD in parents, siblings, and other biological relatives. Approximately 50 percent of the participants reported taking medication to help manage their symptoms, and almost one-third reported taking stimulant medication. About half of the ADHD-diagnosed participants reported not currently taking any medication for the disorder. Many of these participants reported having used medication in childhood; others reported not taking medication due to discomfort with medication side-effects and/or due to a desire to "manage symptoms" on their own. Most participants reported some benefit from receiving an ADHD diagnosis.

Unknown or Missing Data

Significant numbers of the diagnosed participants the were unsure of the exact nature of their ADHD diagnoses, family history of the disorder, who diagnosed them, and what components comprised the assessment or diagnosis of ADHD.[36] In particular, participants who had been assessed or diagnosed in childhood often reported not knowing who diagnosed them, how they were diagnosed, and what formal characteristics defined

[36] This poor history finding further justifies the rationale for conceptualizing the sample as an ADHD "symptom" group.

their diagnoses (e.g., "I was told that I had ADHD, but I don't know what kind."). These participants were included the "diagnosed" group as they often reported having been on stimulant medication, receiving remedial assistance at school (e.g., extra tutoring, being placed in a "special class"), and exhibiting behavioural difficulties (e.g., restlessness).

Comparison of ADHD and Non-ADHD Groups

Tables A3 to A6 present additional background information on the ADHD symptom group and the matched Non-ADHD group. Table A3 presents a comparison of the ADHD and Non-ADHD groups on the background measures used to assign group membership (i.e., scores on symptom checklists). Table A4 presents information on psychosocial factors (e.g., self-reported health, exercise, etc.). Table A5 presents information on academic history, academic functioning, and academic difficulties. Table A6 presents information on self-reported sources of stress.

ADHD Symptom Measures

Consistent with the selection criteria, participants in the ADHD symptom group (i.e., ADHD group) reported more ADHD symptoms than Non-ADHD participants (see Table A3). Non-ADHD participants reported few retrospective childhood symptoms of the disorder; this may reflect a participant self-selection bias in that Non-ADHD participants with no or few symptoms self-selected for the study (J. Clark, personal communication, January 10, 2005). The number of DSM-IV adult ADHD symptoms was consistent with those reported in normal populations (e.g., Murphy & Barkley, 1995).

As measured by the ABC scales, Non-ADHD participants reported an average of one ADHD symptom in childhood and approximately two symptoms in adulthood. ADHD participants reported approximately ten childhood symptoms and around eight ongoing or adulthood symptoms. Inattentive and hyperactive-impulsive symptoms were relatively equally distributed in both cases (i.e., ADHD participants reported around four inattentive and four hyperactive-impulsive adult symptoms; Non-ADHD participants reported approximately one inattentive and one hyperactive-impulsive adult symptoms).

On the WURS, a retrospective measure of ADHD symptoms, the ADHD group obtained means scores that were above the clinical cut-off (i.e., 46). The ADHD group scored around 59 on the WURS; the Non-ADHD group scored around 20 (see Table A3).

Participants in the ADHD group reported more difficulty with self-control traits and behaviours than Non-ADHD participants, as measured by the *Self-Control Scale* (SCS; Tangney et al., 2004; see Table A3). The SCS is a non-clinical self-report measure of self-control traits.

Psychosocial Functioning

Non-ADHD participants reported being in better physical health, having better appetite, sleeping better, having more social support, and being better able to deal with stress than ADHD participants (see Table A4). The majority of both Non-ADHD and ADHD participants reported being involved in some form of regular physical exercise (e.g., walking). ADHD participants reported greater caffeine use (i.e, 3 or more cups per day), alcohol use (1 or more alcohol drinks per day), and smoking than Non-ADHD participants.

Participants in the ADHD group reported significant symptoms of depression, as assessed by the *Center for Epidemiological Studies—Depression Scale* (CES-D; Radloff, 1977; see Table A5). On the CES-D, Non-ADHD participants obtained mean scores of 13; ADHD participants obtained mean scores of around 20. CES-D scores greater than 16 suggest significant depressive symptomatology (McDowell & Newell, 1996).

ADHD and Non-ADHD groups reported similar sources of stress, with exams, career/future, and finances being among the most-reported current stressors (see Table A6). ADHD participants reported more stress stemming from poor time management and organization, grades and coursework, and psychological stress (e.g., feeling stressed, anxiety, and depression) than Non-ADHD students. Conversely, Non-ADHD students reported higher levels of family stress, such as feeling pressured by parents regarding academic performance and career/vocational goals.

Academic History, Functioning, and Satisfaction

ADHD participants reported lower high school grades and university/college GPA (Grade Point Average) scores than Non-ADHD participants (see Table A5). ADHD participants reported having failed more grades or classes in elementary and high school than Non-ADHD participants. Conversely, Non-ADHD students reported greater overall academic satisfaction than ADHD students. Both ADHD and Non-ADHD groups reported some academic difficulties (see Table A5). In particular, ADHD participants reported difficulties with procrastination, inattention, poor time management, poor organization, low motivation, and poor memory. Non-ADHD students reported difficulties with procrastination, poor time management, low motivation, and inattention.

Table A3

Comparison of ADHD and Related Measures for ADHD and Non-ADHD Groups

Variable	Non-ADHD (*M, SD*)	ADHD (*M, SD*)
Childhood DSM-IV Symptoms		
Inattention (I)	.44 (.98)	5.13 (2.88)
Hyperactivity-Impulsivity (H)	.61 (.83)	5.20 (2.67)
Combined HI	1.06 (1.32)	10.31 (4.96)
Adulthood DSM-IV Symptoms		
Inattention (I)	1.09 (1.72)	4.22 (2.62)
Hyperactivity-Impulsivity (H)	1.06 (1.61)	4.33 (2.58)
Combined HI	2.15 (3.00)	8.35 (4.66)
ABC-C		
Inattention (I)	4.35 (3.60)	15.70 (6.63)
Hyperactivity-Impulsivity (H)	4.06 (2.64)	15.70 (6.88)
Combined HI	8.41 (4.78)	31.41 (12.20)
ABC-A		
Inattention (I)	5.26 (4.94)	13.33 (6.05)
Hyperactivity-Impulsivity (H)	4.59 (4.35)	13.09 (6.57)
Combined HI	9.85 (8.43)	26.43 (11.43)
Wender Utah Rating Scale (WURS)	19.69 (8.29)	58.57 (17.78)
Self-Control Scale	86.26 (18.72)	121.52 (20.69)
CES-D (Depression)	13.07 (10.29)	26.20 (15.23)

Notes. *n* = 57 per group. ABC-C = Attention Behavior Checklist for Children. ABC-A = Attention Behavior Checklist for Adults. CES-D = Center for Epidemiological Studies Depression Scale.

Table A4

Comparison of Psychosocial Variables for Non-ADHD and ADHD Participants

Variable	Non-ADHD	ADHD
Health (*M, SD*)	5.30 (1.24)	4.65 (1.26)
Appetite (*M, SD*)	5.39 (1.41)	4.94 (1.66)
Sleep (*M, SD*)	4.67 (1.70)	3.74 (1.85)
Stress Management (*M, SD*)	4.69 (1.23)	3.31 (1.60)
Social Support (*M, SD*)	5.53 (1.54)	4.89 (1.84)
Exercise (%)	94.3	90.7
Caffeine (%)		
None	20.4	20.4
Less than 1 cup per day	11.1	7.4
1 or 2 cups per day	46.3	35.2
3 or 4 cups per day	16.7	27.8
5 or more cups per day	5.6	9.3
Alcohol (%)		
None/Don't drink	29.7	38.9
Less than 1 drink per day	61.1	37.0
About 1 drink per day	7.4	16.7
More than 1 drink	1.9	7.4
Smoking (%)		
None/Don't smoke	83.3	68.5
Less than 1 pack per day	14.8	31.5
About 1 pack per day	1.9	0.0

Notes. *n* = 54 per group. % = percent per group. Health = current health (1 = poor; 7 = excellent). Appetite (1 = poor; 7 = excellent). Sleep (1 = poor; 7 = excellent). Exercise = % students reporting regular exercise activities (e.g., walking). Stress Management = ability to deal with stress (1 = poor; 7 = excellent). Social Support = current social support (1 = low; 7 = excellent).

Table A5

Academic History and Difficulties of Non-ADHD and ADHD Participants

Variable	Non-ADHD	ADHD
Academic History		
HS Grade (*M, SD*)	77.76 (8.42)	72.03 (11.48)
GPA (*M, SD*)	3.08 (.73)	2.80 (.76)
Years of Education (*M, SD*)	14.65 (2.56)	14.28 (2.20)
Satisfaction (*M, SD*)	4.08 (1.45)	3.51 (1.46)
HS Fail Grades (%)	9.3	27.8
Academic Difficulties (%)		
Procrastination	57.4	72.2
Poor time management	51.9	68.5
Poor memory	16.7	31.5
Failing grades	7.4	14.8
Poor organization	18.5	44.4
Learning difficulty	5.6	14.8
Low motivation	33.3	55.6
Poor attention	31.5	70.4
Other difficulties	16.7	27.8

Notes. $n = 54$ per group. % = percent of group. HS Grade = High School Grade (range 0 to 100). GPA = Grade Point Average (range 0.0 to 4.5; estimated from HS scores if missing or unknown for some first year students). Satisfaction = Academic satisfaction (1 = low; 7 = high). HS Fail Grades = % students reporting having failed grade(s) in elementary or high school.

Table A6

Self-reported Sources of Stress for Non-ADHD and ADHD Participants

Variable	Non-ADHD	ADHD
Exams	31.5	27.8
Career/Future	20.4	22.2
Finances	20.4	18.5
Grades/Coursework	9.3	18.5
Relationships	13.0	13.0
Psychological Distress	7.4	16.7
Time/Organization	3.7	18.5
Family Stress	13.0	7.4
Health	7.4	9.3
N/A	3.7	5.6

Notes. n = 54 per group. % = percent per group (percentages may not total 100 as many participants gave multiple responses). Psychological Distress = Anxiety, depression, feeling stressed. Time/Organization = Difficulties related to time management, balancing commitments, and organization. Health = Health concerns, illness.

APPENDIX B

Background History Questionnaires & ADHD Assessment Interview Protocol

Instructions:

Please complete the following questionnaire to the best of your ability by circling the most appropriate answer or by filling in the appropriate blank. Some of the questions are personal in nature.

DEMOGRAPHIC INFORMATION

1. Date of Birth (Year/Month/Day):
2. Age (Years):
3. Gender:
4. Birth Place (City, Province/State, Country):
5. Marital Status: (Single, Common-law, Married, Divorced, Widowed)
6. Years of Education (e.g., completed high school = 12 years):
7. Faculty (e.g., University 1, Engineering):
8. Year of study (e.g., first year):
9. Highest Degree Obtained:
10. Current Occupation:

EDUCATION

11. Academic performance in high school (i.e., average grades; letter A B C D or percent 90-100 90-89, etc.):
12. What was your best/highest mark subject?
13. What was your poorest/lowest mark subject?
14. Did you fail any grades? Which ones?
15. What is your current G.P.A.? (or estimate if not known)
16. How satisfied are you with your current school performance? (1 = "Not at all satisfied", 7 = "Very satisfied") 1 2 3 4 5 6 7
17. What kind of academic difficulties, if any, are you having at this time? Please circle all that apply. Procrastination ... Failing grades ... Low motivation ... Time management ... Organization ... Attention/Concentration ... Memory problems ... Learning disabilities ... ADHD symptoms

Please list any other difficulties:

18: What are your biggest stressors or worries at this time? Please describe (e.g., exams, relationships, health):

HEALTH INFORMATION

19. Are you left- or right-handed? (Left, Abidextrous, Right)
20. How would you describe your physical health? (1 = "Poor", 7 = "Excellent") 1 2 3 4 5 6 7
21. How is your appetite? (1 = "Poor", 7 = "Excellent") 1 2 3 4 5 6 7
22. How well do you sleep? (1 = "Poor", 7 = "Excellent") 1 2 3 4 5 6 7
23. How well do you deal with stress? (1 = "Poor", 7 = "Excellent") 1 2 3 4 5 6 7
24. What kind of exercise do you do?
25 What is your level of social support (i.e., do you have people to talk to when you are feeling down, stressed)? (1 = "Poor", 7 = "Excellent") 1 2 3 4 5 6 7
26. Have you ever had a head injury (i.e., concussion, being knocked unconscious, etc.)? [No, Yes, Don't Know] If yes, please list details:
27. How many caffeinated drinks (coffee, tea, cola) do you drink per day? 0 (don't drink any) ... Less than 1 cup per day ... 1 or 2 cups ... 3 to 4 cups ... More than 5 cups per day
28. How much do you smoke? 0 (don't smoke) ... Less than 1 pack per day ... About 1 pack per day ... More than 1 pack per day
29. How much alcohol you drink? 0 (don't drink alcohol) ... Less than 1 drink per day ... About 1 drink per day ... More than 1 drink per day

ADHD QUESTIONS

30. When was the diagnosis of ADHD made? (childhood, adolescence, adulthood)
31. Who made the diagnosis? (e.g., psychologist, psychiatrist, medical doctor)
32. Who initiated the assessment? (e.g., parents, school, self)
33. What kinds of methods were used to make the ADHD diagnosis? (e.g., psychological tests, questionnaires, interviews, school records)
34. What do you know about the diagnosis? (e.g., what ADHD subtype, associated difficulties, etc.)
35. Was a formal assessment report written? Is it possible to see the assessment report?
36. Do you take medication for ADHD? (e.g., Ritalin, antidepressant)
37. Is there a family history of ADHD? (e.g., parents, siblings)
38. How has the diagnosis impacted on your life?
39. What is the severity of your current symptoms? (e.g., 0 to 100)

Items were based on background research questionnaires created by Drs. John Walker and Dr. Hal Wallbridge at St. Boniface General Hospital, Winnipeg, Manitoba. ADHD questions were based on Murphy & Barkley (1998), and consultation with Dr. D. Patton, Addictions Foundation of Manitoba (personal communication, February 4, 2003).

APPENDIX C

Perl Program to Calculate Gambling Task (GT) Scores

```
@array2 = glob('d:\documents\temp_bgt\*.WIN');
print "@array2";

sub score_BGT {
  my $file = shift(@array2);
  open(FILE, "<$file");
  print "FILE: $file\n";
  my @data = <FILE>;
  my @junk = ();
  my @loops = @data2 = @data[3..$#data];
  my $sum = $win2 = $loss2 = 0;
    my $a1 = $a2 = $a3 = $a4 = 0;
    my $b1 = $b2 = $b3 = $b4 = 0;
    my $c1 = $c2 = $c3 = $c4 = 0;
    my $c1 = $c2 = $c3 = $c4 = 0;

  for (@loops) {
    $line = shift(@data2);
    chomp($line);
      $count++;
    ($s, $n, $c, $win, $loss) = split(/\s+/, $line);
    $win2 = $win2 + $win;
    $loss2 = $loss2 + $loss;
      if (                     $count < 26   ) {$a{$c}++
};
      if ( ($count > 25) and ($count < 51) ) {$b{$c}++
};
      if ( ($count > 50) and ($count < 76) ) {$c{$c}++
};
      if (  $count > 75                    ) {$d{$c}++
};
    next;
   }
  $sum = $win2 + $loss2;
  $name = $file;
  $name = substr($name, 41);
    $a1 = $a{"A\'"};  $a2 = $b{"A\'"}; $a3 =
$c{"A\'"}; $a4 = $d{"A\'"};
```

```
        $b1 = $a{"B\'"};  $b2 = $b{"B\'"}; $b3 =
$c{"B\'"}; $b4 = $d{"B\'"};
        $c1 = $a{"C\'"};  $c2 = $b{"C\'"}; $c3 =
$c{"C\'"}; $c4 = $d{"C\'"};
        $d1 = $a{"D\'"};  $d2 = $b{"D\'"}; $d3 =
$c{"D\'"}; $d4 = $d{"D\'"};
      print "$name\n$win2\t$loss2\t$sum\n";
      print "$a1\t$a2\t$a3\t$a4\t$b1\t$b2\t$b3\t$b4\t";
      print "$c1\t$c2\t$c3\t$c4\t$d1\t$d2\t$d3\t$d4\n";
        $count = 0;
        %a = %b = %c = %d = ();
    }
    @loops2 = @array2;
    for (@loops2) {score_BGT;};
```

Description

As the computerized version of the Gambling Task (GT) does not come with a scoring program of its own, I wrote the above program in Perl. The above program loads participant GT files, which are stored as ASCII text files. The first part of the program calculates the following: total money won ($win2), total money lost ($loss2), and net financial sum (i.e., GT-Net; $sum). The second part creates frequency sum scores for each of the four decks (A to D) across four trial intervals (trials 1 to 25, 26 to 50, 51 to 75, and 76 to 100). The results are printed to the screen. In the current study, the data was subsequently entered into an SPSS data file. Net GT-AB scores (i.e., frequency sums of decks A and B calculated in SPSS).

APPENDIX D

Research Experience Questionnaire (REQ) Items (CPT Depletion Protocol)

1. How much effort did you put into the first computer task?
2. How hard did you work on the first computer task?
3. How much energy did the first computer task require?
4. How difficult was the first computer task?
5. How unpleasant was the first computer task?
6. How tired were you after you finished the first computer task?
7. How frustrating was the first computer task?
8. How much did you enjoy working on the first computer task?
9. How motivated were you to do well on the first computer task?
10. How boring was the first computer task?
11. How much effort did you put into the computer card game?
12. How hard did you work the computer card game?
13. How much energy did the computer card game require?
14. How difficult was the computer card game?
15. How unpleasant was the computer card game?
16. How tired were you after you finished the computer card game?
17. How frustrating was the computer card game?
18. How much did you enjoy playing the computer card game?
19. How motivated were you to do well on the computer card game?
20. How boring was the computer card game?
21. How much effort did you put into the word definition task?
22. How hard did you work the word definition task?
23. How much energy did the word definition task require?
24. How difficult was the word definition task?
25. How unpleasant was the word definition task?
26. How tired were you after you finished the word definition task?
27. How frustrating was the word definition task?
28. How much did you enjoy working on the word definition task?
29. How motivated were you to do well on the word definition task?
30. How boring was the word definition task?

Research Experience Questionnaire (REQ) Items (AR Non-Depletion Protocol)

1. How much effort did you put into the arithmetic task?
2. How hard did you work on the arithmetic task?
3. How much energy did the arithmetic require?
4. How difficult was the arithmetic task?
5. How unpleasant was the arithmetic task?

6. How tired were you after you finished the arithmetic task?
7. How frustrating was the arithmetic task?
8. How much did you enjoy working on the arithmetic task?
9. How motivated were you to do well on the arithmetic task?
10. How boring was the arithmetic task?
11. How much effort did you put into the computer card game?
12. How hard did you work the computer card game?
13. How much energy did the computer card game require?
14. How difficult was the computer card game?
15. How unpleasant was the computer card game?
16. How tired were you after you finished the computer card game?
17. How frustrating was the computer card game?
18. How much did you enjoy playing the computer card game?
19. How motivated were you to do well on the computer card game?
20. How boring was the computer card game?
21. How much effort did you put into the word definition task?
22. How hard did you work the word definition task?
23. How much energy did the word definition task require?
24. How difficult was the word definition task?
25. How unpleasant was the word definition task?
26. How tired were you after you finished the word definition task?
27. How frustrating was the word definition task?
28. How much did you enjoy working on the word definition task?
29. How motivated were you to do well on the word definition task?
30. How boring was the word definition task?

Items on both questionnaires were scored on a 7-point scale (1 = None/Not much; 7 = Very Much). Adapted from samples provided by Mark Muraven (personal communication, March 3, 2003)

APPENDIX E

Pilot Study

The purpose of the pilot study was threefold: (1) to set up the methodology and manipulation checks for the main study, (2) to train experimenters, and (3) to offer a preliminary test of the main hypotheses. The main hypothesis was that participants in the Conners Continuous Performance Test (CPT) Depletion condition would exhibit lower net handgrip stamina scores (i.e., greater ego/resource depletion; HG-Net) than participants in the Arithmetic (AR) Non-Depletion condition. Related hypotheses were that participants in the CPT condition would also report greater fatigue and task difficulty than AR participants. Finally, no significant group differences were expected in mood and arousal between the two groups.

Method

Participants

Thirty-four participants participated in the pilot study. Most were undergraduate students (n = 30) taking introductory psychology at the University of Manitoba and received experimental course credits for their participation. Four participants were graduate students in the Clinical Psychology program at the University of Manitoba. The CPT and AR groups were relatively equivalent in terms of gender, age, and ethnicity. The mean age of participants was 22.28 years (SD = 4.55) and 50.9% were male. In terms of ethnicity, 69.7% were Caucasian and 30.3% were Asian.

Procedure

The procedures largely followed that described previously in this manuscript, with the exception that 20 participants completed an abbreviated version of the study. In the abbreviated version, participants completed the initial handgrip measure, the CPT or AR protocol, the Brief Mood Introspection Scale (BMIS), the second handgrip measure, and the first 10 items of the post-experimental questionnaire.

Results and Discussion

Prior to analysis, the data were inspected for normality, presence outliers, and homogeneity of variance. The data for both groups were relatively normally distributed, and no significant outliers were evident. The difference in variance was not significant, $F(1,33) = 3.687, p = .064$.

Consistent with the main hypothesis, participants in the CPT Depletion condition (M = -17.44 seconds, SD = 23.26) exhibited significantly lower HG-Net scores than participants in the AR Non-Depletion condition (M = 5.53 seconds, SD = 15.10), $t(32) = 3.41, p < .001, d = 1.21$. The group means of the CPT Depletion and AR Non-Depletion group HG-Net scores were each compared against zero to rule out alternate hypotheses (e.g., increased self-control in the AR group; Muraven et al., 1998). Consistent with the resource depletion hypothesis, CPT Depletion group HG-Net scores (M = -17.44 seconds, SD = 23.26) were significantly below zero, $t(16) = -3.09, p = .007$ (2-tailed), $d = 1.09$. Conversely, AR Non-Depletion group HG-Net scores (M = 5.53 seconds, SD = 15.10) were not significantly different from zero, $t(16) = 1.51, p = .151$ (2-tailed), $d = .15$.

Based on previous research, it was hypothesized that both CPT Depletion and AR Non-Depletion groups would be relatively equivalent in terms of mood and arousal. The groups were compared on the Brief Mood Introspection Scale Pleasant-Unpleasant

(BMIS-PU) and Aroused-Calm (BMIS-AC) scales to test these hypotheses. There was no significant difference in mood between AR Non-Depletion (*M* = 77.06, *SD* = 10.25) and CPT Depletion (*M* = 73.18, *SD* = 13.04) groups, $t(32) = .97$, $p = .342$ (2-tailed), $d = .36$. There was also no significant difference in arousal between AR Non-Depletion (*M* = 41.65, *SD* = 7.57) and CPT Depletion (*M* = 37.41, *SD* = 6.02) groups, $t(32) = 1.81$, $p = .081$ (2-tailed), $d = .63$.

Participant responses to the Research Evaluation Questionnaire (REQ) were compared in terms of fatigue and task difficulty. The REQ is a 10-item post-experimental questionnaire developed by the primary investigator, based on items used in previous self-control research (e.g., Muraven et al., 1998). REQ item 6 assessed fatigue. Consistent with the main hypothesis, and the BMIS fatigue results, there was a trend suggesting that the CPT Depletion group (*M* = 2.88, *SD* = 1.45) experienced higher fatigue than the AR Non-Depletion group (*M* = 3.71, *SD* = 1.86), $t(32) = 1.44$, $p = .080$ (1-tailed), $d = .51$. REQ item 4 assessed task difficulty. Consistent experimental hypotheses, there was a trend difference in reported difficulty between CPT Depletion (*M* = 4.29, *SD* = 1.64) and AR Non-Depletion (*M* = 3.34, *SD* = 1.84) groups, $t(32) = 1.59$, $p = .060$ (1-tailed), $d = .56$. That is, participants in the depletion condition appeared to find the task more difficult than participants in the non-depletion condition.

Taken together, the pilot study results suggested that the Conners' CPT would work as a resource depletion task in the current study.