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EXAMINING BEHAVIORAL AND NEURAL RESPONSES TO SMOKING CUES IN THE CONTEXT OF THE STRENGTH MODEL OF SELF-CONTROL

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ABSTRACT

This thesis was based on Baumeister and Muraven's "Strength Model of Self-Control", which proposed that self-regulation is like a depletable muscle. The analyses of data stemed from a study that examined behavioral and neurobiological responses in cigarette smokers who were provided with a cigarette and an opportunity to smoke following twelve hours of nicotine deprivation. Smokers with fatigued self-control resources had higher responses on a self-report measure of craving, as expected to fit with the self-control model. Fatigued participants were expected to show decreased dorsolateral prefrontal cortex (DLPFC) activity as assessed through functional magnetic resonance imaging (fMRI). The direction of the relationship was as expected, but no significant correlation was found. These results add to the existing body of knowledge in this area, and hopefully will guide the development of novel smoking cessation therapies.

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Introduction

Cigarettes are highly addictive, perhaps comparably to other drugs of abuse, such as cocaine and heroin (Stolerman & Jarvis, 1995). Smokers often experience a very strong desire, or craving, to smoke after even relatively brief periods of abstinence (Tiffany, Cox, & Elash, 2000). Moments of intense craving often are provoked by environmental cues, and are associated with immediate relapse (Ferguson & Shiffman, 2009). Episodic craving is potent; in one real-time study, half of the subjects smoked within 11 minutes of the initiation of the craving (Shiffman, et al., 1997). However, studies also show that individuals can overcome their cravings and continue to abstain, indicating the therapeutic potential in aiding smokers overcome cravings (Ferguson & Shiffman, 2009).

Successfully overcoming craving can be achieved with active coping mechanisms. Cognitive techniques, such as relaxation and self-talk, and behavioral techniques, such as exercise, both appear to be effective at preventing relapse for those trying to quit (Ferguson & Shiffman, 2009). In one study, individuals who used coping were 12 times more likely to withstand a craving than those who did not, while failure to cope was almost perfectly correlated with a lapse (Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996).

However, attempting quitters often fail, even with the use of such coping techniques. Shiffman and colleagues (1996) found that 81% of lapses occurred even with the use of coping techniques. Exploring the reasons for this failure may reveal new techniques to aid attempting quitters. One possible reason discussed here is the failure of self-control.

Self-Control Model

Muraven and Baumeister (2000) define self-control as an attempt to alter a habituated behavioral or emotional response in order to maximize long-term benefit. Self-control is exerted when an individual must follow rules or override immediate desires to delay gratification. Overcoming habitual responses may be costly in terms of energy and mental resource. Muraven and Baumeister's model of self-control represents this resource as finite and depletable. They compare the resource to a muscle or strength that, when used, may become fatigued and less efficient. The resource may be replenished with rest, but is depleted faster than it is renewed.

This model predicts that when self-control is exerted, subsequent efforts will be less successful because the resource has been depleted. It is argued that all forms of self-control tap into a common strength. Thus, in the case of two consecutive self-control attempts, the second may be less successful even if they are in unrelated domains. For example, this model was applied when subjects were deprived of food and then exposed to tempting sweets (Baumeister, Bratslavsky, Muraven, & Tice, 1998). One group was allowed to eat the treats, and another group was given the sweets and radishes and instructed to only eat the radishes. A third group was not exposed to food. All groups then attempted unsolvable puzzles that, the authors assumed, required self-control to continue in the face of failure and frustration. The group that had previously used self-control to eat only the radishes and not the dessert showed decrements in time spent attempting these impossible puzzles compared with the two groups that had not denied any immediate desires of treats.

Support for this model also comes from longitudinal research examining practice-related changes in the ability to exert self-control. Specifically, Baumeister and collegues tested that hypothesis that, like a muscle, the size of the resource may increase over time with exercising of self-control. Muraven, Baumeister, and Tice (1999) found that individuals who practiced self-control (e.g. improving posture) for two weeks had improved performance in a hand-grip task following a thought-control exercise compared with the no-practice control group.

The depletable strength model has found support from a variety of studies and can be applied to addiction. Laboratory experiments found that individuals who engaged in a thought control exercise later drank more alcohol than individuals who performed an equally difficult arithmetic set that did not require self-control (Muraven, Collins, & Nienhaus, 2002). In real-world applications, Muraven, Collins, Shiffman, and Paty (2005) showed that on days when social drinkers experienced more self-control demands, subjects were more likely to exceed self-imposed alcohol intake limits. Similarly, when subjects exceeded their limits, they reported more negative affect the next day and were more likely to exceed drinking limits again on the next night, a downward spiral that may contribute to the development of problem drinking (Muraven, Collins, Morsheimer, et al., 2005).

While there is much support for behavioral implications of the self-control model, researchers have not studied it in relation to cue-elicited craving. Additionally, not much is known about the neurobiological underpinnings that underlie depletion of the resource.

Dorsolateral Prefrontal Cortex

This thesis borrows from recent neurophysiological models of cognitive self-control. According to such perspectives, the dorsolateral prefrontal cortex (DLPFC) is a likely candidate for its involvement in self-control (Kane & Engle, 2002). The prefrontal cortex, the dorsolateral area in particular, appears to be important for working memory circuitry.

The “attention control” aspect of working memory keeps information active and accessible if relevant to goals and tasks (Kane & Engle, 2002). This process is particularly important for overriding distracting information and interfering desires. As an example relevant to this study, attention control can regulate the competing desires for task goals and habitual responses. Without distracters, information could be easily accessed from long term memory storage. However, memories retrieved in the presence of interference are more likely to be incorrect and irrelevant. Thus, executive attention is critical to focus the mind and guide behavioral responses. Like self-control, executive attention appears to consume a finite resource. When attention is taxed by one task, performance will suffer if additional tasks are added. Without successful attention control, behavior may reflect “goal neglect” and be disorganized and inappropriate.

The DLPFC is likely highly involved in executive attention (Kane & Engle, 2002). Because this construct overlaps with general working memory in behavioral definitions, the brain structures responsible for these functions might be the same or similar. Much of working memory function relies on the DLPFC, and some evidence points to its role in attention control. While all of attention is probably not involved with working memory or supported by the DLPFC, executive attention that moderates task direction and distracting interference is the component investigated here. This area retains task demands in an active state and helps to deactivate competing information through lateral inhibition. The DLPFC works in association to bias processing towards task-oriented information maintenance and retrieval.

Brain imaging studies reveal that activation of the DLPFC during divided attention tasks depends on the complexity of the component tests (Kane & Engle, 2002; Klingberg, 2000). When the tests are complex and require considerable use of the DLPFC, such as delayed memory or card sorting, activation of this area and behavioral results will show deficits. However, when the tests are minimally difficult, such as making simple assessments on object attributes, divided attention increases DLPFC activation.

One important component of executive attention is set shifting, in which the task at hand must be kept relevant while attention is moved to and from this demand (Robbins, 2007).

Primed and habitual responses must be overridden for successful goal-directed behavior. Attention is controlled by keeping active memories of relevant information during this shift between the task and other response tendencies. Results from Wisconsin Card Sorting Tasks indicate that the DLPFC is active during, if not critical to, the frequent set shifting required by this task. Damage in this area of the brain creates deficits in success in the task.

The DLPFC may be responsible for balancing task goals and habitual responses, such as the desire to quit smoking and nicotine addiction. As self-control may be defined as altering habit for a long-term goal (Muraven & Baumeister, 2000), the DLPFC appears to be a strong candidate for the neural correlate of this construct. This region is examined in this study as the possible basis for self-control.

Current Study

This study uses data from a project that examined responses in smokers who were deprived of cigarettes for 12 hours. While scanned using functional magnetic resonance imaging (fMRI), subjects were exposed to neutral and smoking cues, including one of their own cigarettes. Participants were later given an opportunity to smoke. Specific hypotheses are derived from the self-control strength model previously discussed.

Aim 1: To examine the relationship between self-control depletion and self-reported craving elicited by a smoking cue. Based upon prior work, participants who reported mental depletion were expected to report increased craving. That is, those who were the most fatigued from their twelve-hour smoking cessation may have exerted and depleted self-control to the greatest extent, leaving them with few resources to reduce or resist their craving.

Aim 2: To extend previous work by examining the relationship between the dorsolateral prefrontal cortex and self-control. The DLPFC may be the neurological basis for self-control capacity. As described above, mentally depleted individuals may have consumed more self-control. As this area of the brain may be responsible for this executive function, the DLPFC was expected to show less activation in depleted participants when they were given a cigarette, relative to those who were not as depleted.

Method

Participants

Data used for this study was collected as a part of a previously conducted experiment in which 57 adults aged 18 to 45 participated. Only males were recruited because research suggests there are gender differences in neurobiological responses to drug cues (Kilts, Gross, Ely, & Drexler, 2004). Participants were recruited through advertisement in local newspapers and in the community. Interested subjects were healthy smokers who were willing to quit smoking, enroll in a smoking cessation program, and participate in paid studies.

Eligibility interviews were conducted by telephone. Participants must have smoked 15 to 40 cigarettes per day for at least the past two years. Individuals who were addicted to any substance other than nicotine and caffeine, were illiterate, or had a medical condition that increased the health risk associated with nicotine use were excluded. Participants also were required to pass an MRI safety screen. Only right-handed subjects were used because many brain functions are lateralized. Written consent was obtained and all procedures were approved by the Institutional Review Board of the University of Pittsburg. Participants were paid for their involvement.

Questionnaires

Participants completed a questionnaire battery assessing individual differences. For a full description, see Wilson (2008). The present study focused on the following questionnaire measures:

State Self-Control Capacity Scale (SSCCS). SSCCS measures level of energy and fatigue (Twenge, Muraven, & Tice, 2007). The measure consists of 25 descriptive items (I feel mentally exhausted"), each rated on a 7-point scale (1 = "not true", 7 = "very true"). Eighteen items are reversed scored. Initial studies indicate the scale has good internal reliability ($\alpha = .94$) and scores correlate with daily self-control demands, general well-being, and laboratory manipulations of self-control resources (Twenge, et al., 2007). A total score of mental fatigue was taken by summing responses to all 25 items (possible score can range from 25 to 175). A higher score indicates more mental fatigue.

Fagerström Test of Nicotine Dependence (FTND). FTND measures level of nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). The scale consists of 6 items examining time until first cigarette, number of cigarettes smoked per day, desire to smoke in forbidden areas and during sickness, and preference for morning smoking. The test has been correlated with biochemical markers of dependency, including carbon dioxide exhalation and salivary nicotine. It has also been found to reliably predict smoking cessation. Score range is 0 to 10, with a score above 4 indicating dependence and a score about 6 indicating severe dependence.

fMRI

In addition to a working memory task (not described herein; for a description of the task see Wilson, 2008), participants performed a cue-exposure and coping task adapted from prior research (Wilson, Sayette, Delgado, & Fiez, 2005). Each run began with a 48-second baseline period in which participants were told to relax and remain still with their eyes open. After this period, an object was placed in the participant's left hand and a prerecorded message identifying the object was played over an intercom. Participants were instructed to passively look at the object, which they held for 74 seconds. A camera system focused on the object and projected to a display inside the MRI magnet allowed participants to see what they were holding.

Participants completed three runs of this task, using a small notebook, a roll of a tape, and a cigarette of the participants preferred brand. The notebook and tape were neutral objects designed to elicit relatively small changes in affect. The first run was a practice test to acclimate the participants to the task and was excluded from analysis. Presentation of the items was fixed in the above sequence because there is strong evidence that drug cue exposure affects responses to later cues (e.g., Hutchison, Niaura, & Swift, 1999; Wilson, Sayette, Fiez, & Brough, 2007).

Immediately prior to the presentation of the cigarette, participants were informed that they would be holding a cigarette and that they should use their trained coping technique (see below) the entire time they were holding this item. They were also told they would be given the opportunity to smoke immediately after this task. Upon presentation of the cigarette, a prerecorded message informed participants via intercom that they would be removed from the scanner in 40 seconds and could smoke if they chose to do so.

Procedure

Screening/training session. Following the initial telephone screening, eligible participants came into the laboratory for a training session and to complete several questionnaires and memory tests. A carbon monoxide sample was also taken to confirm smoking status and to provide a baseline level. Participants were then trained in one of two cognitive coping techniques. Half of the group learned a method in which they were to concentrate on the benefits the smoker would experience if they successfully quit. The other half of the group learned a technique in which they were to concentrate on the positive effects an individual close to the smoker would have if the quit attempt was successful. The effects of strategy are not a focus of the present study and will not be described in this paper.

When participants were trained in these coping methods, they were first given a brief description of the technique. They were then instructed to use the coping strategy while being presented with a series of smoking-related pictures. After each training trial, participants recorded what they were thinking about during the presentation of the picture. An experimenter reviewed their responses and used the material to provide feedback and guide the participant in learning the strategy.

After successfully learning the coping technique, participants were instructed to abstain from smoking for 12 hours prior to the experimental session, as well as drugs and alcohol for 24 hours prior. The experiment was scheduled for 12 hours after the initiation of a quit attempt to model the early stages of cessation. Before leaving the laboratory, participants enrolled in one of two randomly assigned local programs that offered free assistance in quitting smoking.

Experiment sessions. Experiment sessions were scheduled between 11 AM and 2 PM on a later day. A second carbon monoxide sample was taken to ensure compliance with abstaining from smoking. Participants then presented a pack of their cigarettes and a lighter, and completed the SSCCS, as well as other questionnaires. Additionally, urge to smoke was rated on a scale of 0 (Absolutely no urge at all) to 100 (Strongest urge I've ever experienced).

Participants were told they would be able to smoke later in the experiment. This information was presented in front of a sign indicating that the room was a "smoking room." This area was close to the MRI scanning room, enhancing the appearance that the participant would be able to smoke immediately after leaving the scanner. Participants were also asked to review coping technique guidelines and informed they would be using the strategy later in the experiment.

Participants were then placed in a conventional 3-Tesla head-only Siemens Allegra scanner equipped with a standard transmit/receive head coil. A 40 slice oblique-axial structural series (3.125 x 3.125 x 3.0 mm voxels) was acquired parallel to the anterior commissure-posterior commissure plane using a standard T2-weighted pulse sequence. While the participant completed the cue-exposure task and a working memory task, functional images were collected in the same plan as the structural series with coverage limited to the 38 center slices using a one-shot echo-planar imaging (EPI) pulse sequence [TR = 2000 ms, TE = 25 ms, FOV = 20 cm, flip angle = 79°].

Additional urge ratings were recorded after the second and third trials of the cue-exposure task while the participant was still holding the tape or cigarette. Participants were then removed from the scanner and given the opportunity to smoke. Those who chose to smoke were taken outside and given one of their cigarettes. All participants subsequently completed additional questionnaires (see Wilson, 2008), debriefed, paid, and allowed to leave the laboratory.

Processing of fMRI Data

Analysis of fMRI data was conducted using the Neuroimaging Software package (NIS 3.5), developed at the University of Pittsburgh and Princeton University, as implemented in the Functional Imaging Software Widgets graphical computing environment (Fissell, et al., 2003), and the Analysis of Functional NeuroImages software package (AFNI 2.6; Cox, 1996). Prior to statistical analysis, a series of preprocessing steps were employed to correct for artifacts and individual differences in anatomy. Each participant's data were corrected for motion using Automated Image Registration (AIR 3.08; Woods, Cherry, & Mazziotta, 1992) and adjusted for drift within and between runs. Data for which motion exceeded 3 mm or 3° were excluded from subsequent analysis. Structural images from each participant were co-registered to a common reference anatomy. Subsequently, functional images were globally mean-normalized and smoothed using a three-dimensional Gaussian filter (4-mm full width at half maximum) to account for anatomical differences between participants. Group-based statistical images were transformed into standard stereotaxic space (Talairach & Tournoux, 1988) using AFNI.

Additional preprocessing steps were conducted for fMRI data from the smoking cue exposure task. Specifically, for each participant, fMRI signal was averaged over the final 48 seconds of the cue exposure epoch separately for the tape and cigarette/coping conditions; signal collected during the initial 26 seconds of cue exposure was removed to allow for stabilization of responses associated with the instructions identifying the object and, for the cigarette, informing participants that they would have an opportunity to smoke soon. Data also were averaged over the 48 second baseline epochs and a measure of percent change from the preceding baseline period was calculated for both the tape and cigarette cues. This percent change measure, which was calculated for both functionally-defined ROIs and on a voxel-wise basis, was the blood oxygen level-dependent (BOLD) response of interest for all subsequent analyses of fMRI data.

Results

Sample Description

Usable data were collected from a total of 57 participants. Coping-strategy groups were not significantly different in many psychosocial and behavioral variables, including age, number of cigarettes smoked per day, number of quit attempts, level of nicotine dependence, and several other variables (*ps* > .1; see Wilson, et al. 2008), so data has been collapsed across groups. Participants had an average age of 33.61 years (SD = 8.52) and smoked 20.18 cigarettes per day (SD = 6.02). They averaged 3.59 prior quit attempts (SD = 5.62). Their average level of nicotine dependence, as assessed by the FTND on a scale of 0 to 10, was 4.81 (SD = 0.22).

Craving and Self-Control

As abstaining from smoking overnight and resisting the urge to smoke may both require self-control, Aim 1 hypothesized that depleted participants would report more craving when exposed to a cigarette. A Pearson correlation was conducted to assess the relationship between cue-elicited craving (i.e., the magnitude of self-reported craving during the exposure to the cigarette cue) and self-control depletion, as assessed by the SSCCS. As predicted, there was a positive correlation between the two variables, $r(57) = 0.43$, $p = .001$; see Figure 1. That is, participants whose self-control was more depleted reported more craving when holding their cigarette.

Craving and DLPFC

As the DLPFC may be involved in self-control, Aim 2 hypothesized that this area of the brain would show decreased activation in depleted participants when exposed to a cigarette and given an opportunity to smoke. To test this hypothesis, a Pearson correlation assessed the relationship between the SSCCS and the DLPFC activation while the participant was holding their cigarette. Correlations were conducted separately for the left and right DLPFC. On the right side, there was a weak, non-significant relationship in the negative direction, $r(57) = -0.20$, $p = .12$; see Figure 2. With the left DLPFC, there were similar results, $r(57) = -0.21$,$p = .124$; see Figure 3. Though these results do not meet significance criteria of $p < .05$, they approach a trend towards significance of $p < .1$. The negative direction of the relationship was expected. Individuals who report more self-control depletion showed somewhat less activation of both of their DLPFC during the cue exposure task.

Discussion

Current Study

The overarching aim of this study was to advance our understanding of the mechanisms supporting self-control in individuals attempting to quit smoking using secondary analysis of data from a previously completed functional magnetic resonance imaging study. Participants who were involved in this study indicated an interest in quitting smoking. They were trained in coping techniques and asked to use the techniques when exposed to a cigarette. This procedure models the conflict experienced by an attempting quitter struggling with the divergent desires to smoke and to abstain and provides a useful framework for investigating self-control during a quit attempt.

Using these data, the present thesis examined the relationship between depletion of self-control resources and behavioral and neurobiological responses to a cigarette cue in individuals who were in the early phases of a quit attempt. The first aim of the current research was to determine whether self-control depletion was related to self-reported craving to smoke during cue exposure. It was hypothesized that these variables would be positively correlated; that is, the subjects who were more depleted would report a greater craving. The second aim was to examine the relationship between self-control depletion and activation of the DLPFC, a region of the brain strongly linked to self-control. It was hypothesized that self-control depletion would be negatively correlated with activation of the DLPFC during cue exposure, showing less activation when depleted subjects were exposed to a cigarette.

As hypothesized, self-control depletion and craving during cue exposure were positively correlated. The relationship between self-control depletion and DLPFC activation, however, was not significant. The association did approach trend significance, and was in the negative direction. This direction was as expected. As described further below, these results provide partial support for the hypotheses of the current study and highlight the applicability of the self-control strength model to drug cue reactivity.

Self-Control

This study was based off a model of self-control as a depletable resource (Muraven & Baumeister, 2000). As self-control is exerted, it is consumed and is no longer available for further use until it is replenished. The two aims examined here may lend some support to this model.

As self-control is depleted, reported craving increases. This finding supports the model because depleted participants did not appear to have the self-control to resist or reduce their urge to smoke. Like a muscle, self-control is less effective when used repeatedly without time for recovery. As self-control consumes a finite resource, depletion affects all domains, even unrelated ones (Muraven & Baumeister, 2000). Ceasing cigarette use overnight and resisting the urge to smoke each may rely on self-control, and efforts become less successful when the resource is depleted. This effect is broadly consistent with previous findings. Specifically, Muraven and Shmueli (2006) found that the smell of alcohol, which presumably triggered craving in social drinkers, worsened performance in self-control tasks like squeezing a handgrip. Additionally, as described above, on days when social drinkers experienced more self-control demands, they exceeded self-imposed limits and drank more (Muraven, Collins, Shiffman, & Paty, 2005).

Though the results were not significant, self-control depletion was related to decreased DLPFC activation during the cigarette cue exposure. The direction of this result was consistent with previous findings. This area of the brain has been previously shown to be important in cognitive control. The DLPFC is critical to maintaining goals in the face of distractions (Kane & Engle, 2002); in this case, the desire to successfully quit smoking competes with the immediate desire for a cigarette. DLPFC activity has been shown to increase when self-control is exerted (Hare, Camerer, & Rangel, 2009). Thus, individuals who have less self-control resource to use show decreased activation. The lack of significance was an unexpected finding. One possible explanation is that participants were asked to engage in coping techniques while exposed to the cigarette. This process may have engaged working memory, even in the most depleted individuals. Also possible is a larger network involved in self-control, beyond just the DLPFC.

Potential Implications of the Current Findings

Findings may have potential for use in therapeutic cessation programs, and future study is needed to elucidate possibilities. Because self-control depletion is correlated with increased urge, increasing self-control capacity may prolong the ability withstand craving episodes. Practicing self-control has been shown to improve performance in different domains of executive control (Muraven, et al., 1999), and this finding may be applied to craving as well. Decreasing depletion could also reduce cravings. There is preliminary support that sleep and positive emotional experiences help to restore self-regulation resources (Baumeister, 2003). Further study could show if these findings are applicable to craving reduction, as well.

Activation of the DLPFC could also be beneficial. Using repeated high-frequency transcranial magnetic stimulation over this area, smokers have reported fewer cravings and have smoked fewer cigarettes (Amiaz, Levy, Vainiger, Grunhaus, & Zangen, 2009). If this relationship is mediated by changes in self-control, support for the neural basis of the self-control model may be strengthened.

Limitations

While the direction of the DLPFC finding was as expected, the relationship with self-control did not reach significance. The support for this brain region's involvement in the processes outlined by the self-control model is imperfect and awaits further evidence. Any possible explanation for the lack of significance would need direct exploration.

Summary and Future Directions

Much evidence exists to show that coping techniques are important in aiding quitting smokers withstand a craving episode. However, these techniques often fail. One possible reason for failure, explored here, is self-control depletion. Two aims sought to examine self-control within the context of a modeled quit attempt. It was found that participants who reported more self-control depletion also reported more craving when exposed to a cigarette. These results support the hypothesis that those who were fatigued from 12 hours of smoking cessation were less able to resist feeling the urge to smoke. More broadly, this finding is consistent with previous research examining the strength model of self-control. The second aim was to examine the possible neural basis for the self-control model, with a focus on the role of the DLPFC. Results were not significant, although the direction of the relationship between activation and self-control depletion was negative, as expected. Participants reporting more depletion showed less activation in this brain region.

Further work is needed to assess a fuller picture of the neural correlates to the self-control model. A network beyond the DLPFC may be involved, and a narrower study without the use of coping techniques may help elucidate the involvement of this brain area. Behaviorally, future work may study if increasing or restoring self-control lessens cue-induced cravings.

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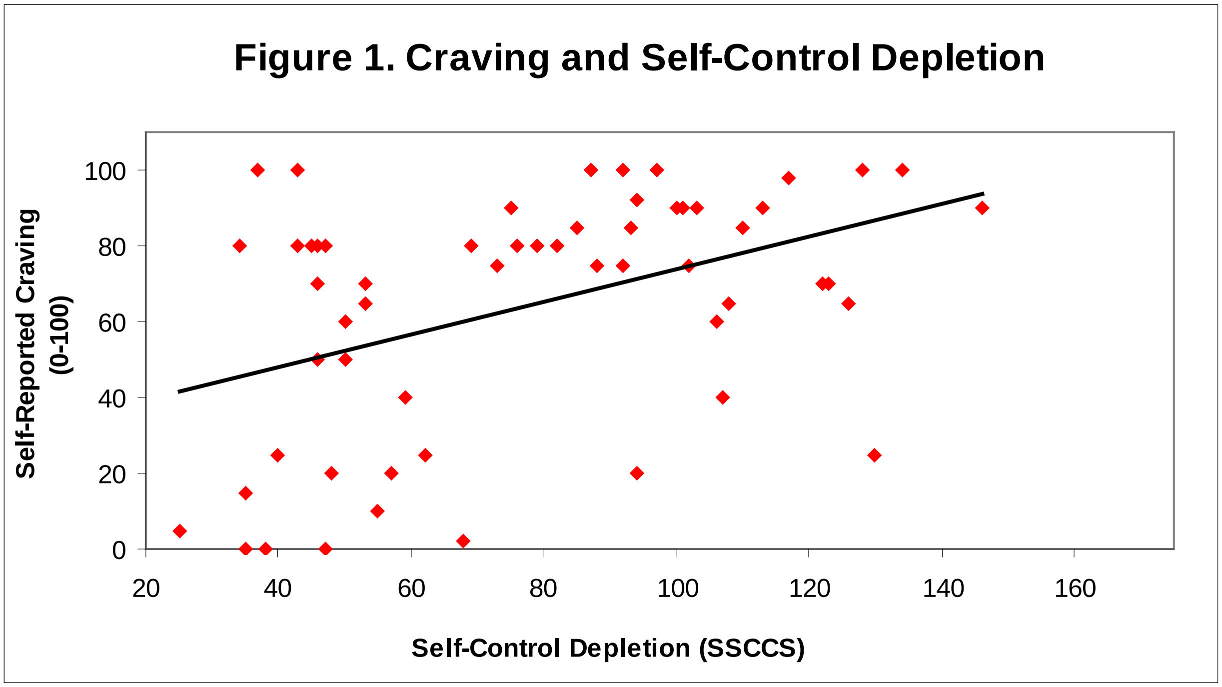
Figure 1. Craving and Self-Control Depletion
Self-Reported Craving (0-100)
100
80
60
40
20
0
20
40
60
80
100
120
140
160
Self-Control Depletion (SSCCS)

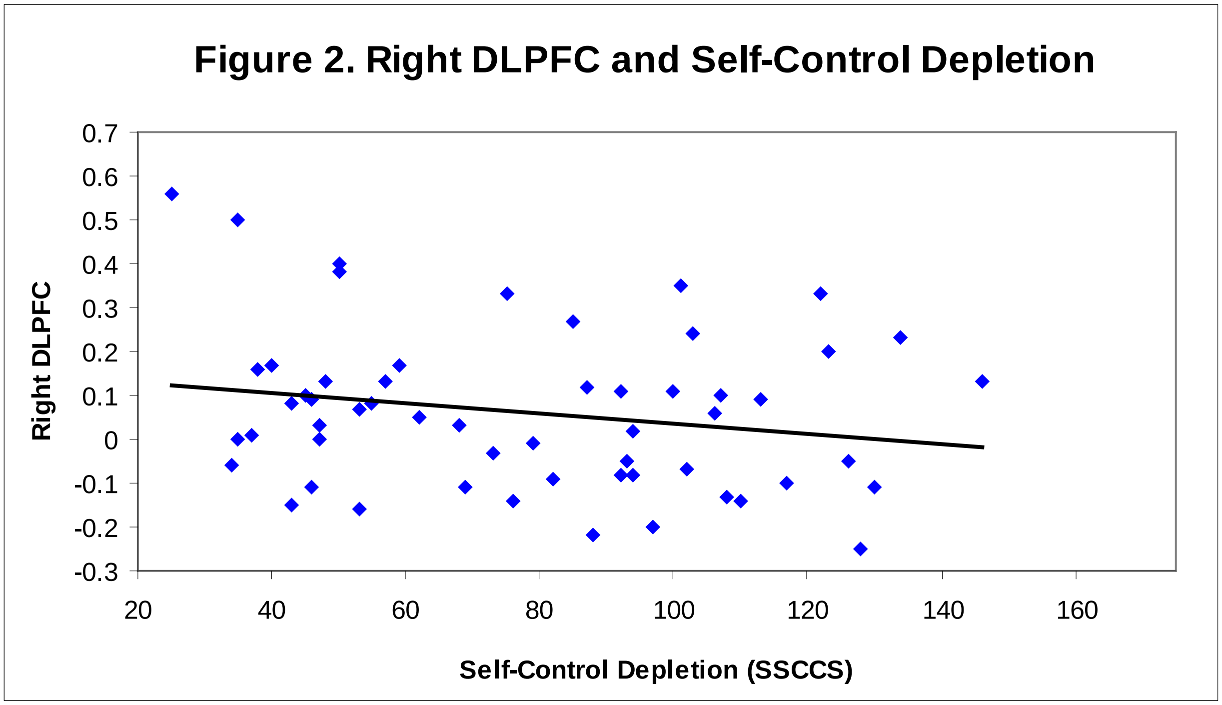
Figure 2. Right DLPFC and Self-Control Depletion
Right DLPFC
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
20
40
60
80
100
120
140
160
Self-Control Depletion (SSCCS)

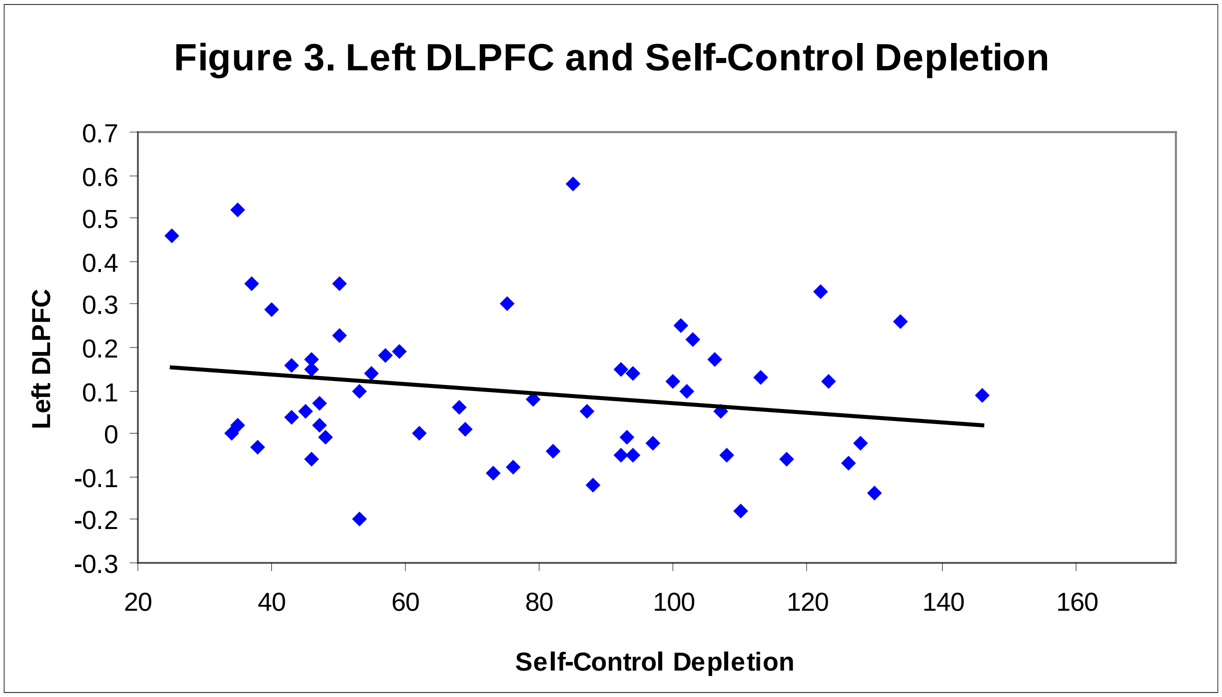
Figure 3. Left DLPFC and Self-Control Depletion
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
Left DLPFC
20
40
60
80
100
120
140
160
Self-Control Depletion

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EDUCATION

2006-2010 **PENNSYLVANIA STATE UNIVERSITY, SCHREYER HONORS COLLEGE** University Park, PA
Honors Candidate for Bachelor of Science in Psychology, Neuroscience Option

2002-2006 **RADNOR HIGH SCHOOL** Radnor, PA

PUBLICATIONS

Einstein E, Patterson C, Hon B, Regan K, Reddy J, Melnikoff D, Mateer M, Johnson B, & Tallent M. "Somatostatin Signaling in Neuronal Cilia is Critical for Object Recognition Memory". J Neurosci. In press.

POSTER PRESENTATIONS

Regan K, Wilson S. “Examining Behavioral and Neural Responses to Smoking Cues in the Context of the Strength Model of Self-Control.” Undergraduate Research Exhibition 2010, University Park, PA.

Melnikoff D, Einstein E, Patterson C, Regan K, Mateer M, & Tallent M. “Somatostatin Signaling in Neuronal Cilia is Critical for Object Recognition Memory and cAMP-dependent LTP.” Neuroscience 2009, Chicago, IL.

RESEARCH EXPERIENCE

Fa ’09 - Spr ’10 **SMOKING RESEARCH LAB** University Park, PA
Research Assistant
Penn State University, Dept. of Psychology

- Study of cognitive and neurobiological changes in smokers attempting to quit
- Research for completion of thesis work for Schreyer Honors College
- Processing of functional magnetic resonance imaging (fMRI) data
- Principal Investigator: Stephen Wilson, PhD

Sum. ’08, ’09 **SUMMER UNDERGRADUATE RESEARCH FELLOWSHIP** Philadelphia, PA

Student Fellow

Drexel University College of Medicine, Dept. of Pharmacology and Physiology

- Study of memory deficits in genetically- and pharmacologically-altered mice.
- Electrophysiology, immunohistochemistry, behavioral studies (Morris Water Maze, Object Displacement Test, Novel Object Recognition)
- Principal Investigator: Melanie Tallent, PhD

Spr.-Fa. 2007 **TODDLERS INTO KINDERGARTENERS EMOTIONS STUDY** University Park, PA

Research Assistant

Penn State University, Dept. of Psychology

- Longitudinal study of toddlers’ emotional expression, heart rate, and cortisol release in stressful situations.
- Principal Investigator: Kristin Buss, PhD

HONORS AND AWARDS

Fall 2009 – Spring 2010	*Lynn Maneval Memorial Scholarship*
Fall 2008 – Spring 2010	*Psi Chi: The National Honors Society in Psychology*
Spring 2008	*President Sparks Award*
Spring 2007	*President’s Freshman Award*
Fall 2006 – Spring 2010	*Dean’s List*
Fall 2006 – Spring2010	*Academic Excellence Scholarship*
Fall 2006 - Spring 2007	*National Merit Scholarship*
Spring 2006	*Society of Women Engineers, Honor in Science and Mathematics*
Fall 2005 – Spring 2006	*National Honor Society*
Fall 2005	*Distinguished Honors Scholar*
Spring 2005	*Summa cum Laude, National Latin Examination*

SKILLS AND ACTIVITIES

- Experienced with Microsoft Office, Minitab, SPSS
- CPR/AED certified
- Student Red Cross Club – On Site Coordinator Chair, PSU Dance Marathon, Schreyer Honors Orientation mentor, Homecoming committee, volunteer at Foxdale Retirement Community
- Proctor for Department of Psychology