

## Changes in Executive Function Following Short-Term Tobacco Cessation Therapy in College Students

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Received date: November 06, 2017; Accepted date: November 26, 2017; Published date: December 03, 2017

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### Abstract

**Objective:** Evidence has been accumulating regarding the role of executive deficits in nicotine addiction; however, little is known as to whether executive abilities change as a function of treatment for nicotine dependence. The purpose of this study was to investigate whether executive function improves following short-term tobacco cessation therapy.

**Methods:** College students (N=17) expressing an interest in tobacco cessation therapy involving Motivational Interviewing Therapy with or without the nicotine patch were administered the self-report Frontal Systems Behavioral Scale (FrSBe), the performance-based Delis-Kaplan Executive Function System (D-KEFS) and the Fagerstrom Test of Nicotine Dependence (FTND) prior to treatment and approximately 1.5 months later. A group of non-smoking college students (N=19) was also administered the same measures of executive function across the same time period.

**Results:** Prior to treatment smokers had significantly higher FrSBe Apathy subscale scores compared to non-smokers. Acute tobacco cessation therapy significantly decreased nicotine dependence as measured by the FTND. After controlling for pre-treatment scores, a significant difference emerged between tobacco cessation participants and non-smoking controls on post-test FrSBe Disinhibition scores. Post hoc analyses revealed a significant improvement in FrSBe Disinhibition scores among tobacco cessation participants, but no change among non-smokers.

**Conclusion:** While caution is warranted due to the small sample size of this study, these results suggest self-report measures of executive function maybe more sensitive to executive deficits among smokers and change following short-term tobacco cessation therapy, particularly measures indicative of an improved ability to inhibit impulses and behavior. These results also highlight the multidimensional nature of executive function.

**Keywords:** Executive function; Tobacco cessation; Disinhibition; Apathy; Prefrontal cortex; Tobacco dependence

### Introduction

The term executive function represents a shorthand description of a complex set of processes central for goal directed behavior and managing cognitive, emotional and behavioral activities particularly during active and novel problem solving. Multiple behaviors fall under the umbrella of executive function including; planning, attention, working memory, monitoring, decision-making, inhibitory control, emotion regulation and cognitive flexibility among others [1-3]. Executive abilities are generally believed to be localized within the sub-regions of the prefrontal cortex and related circuitry [4,5]. A significant literature links deficits in executive function and drug addiction and this relationship is now viewed by many as integral to the development and maintenance of drug addiction [6,7] as deficits in executive function have been found to both predate the development of addiction [8,9] as well as worsen as a function of repeated drug exposure [10]. Moreover, structural and functional imaging studies have linked addiction with changes in the prefrontal cortex and

impaired performance among drug addicted individuals has been observed on neuropsychological tests of executive function [11-13].

While the role of executive dysfunction in drug addiction has been previously well established across a variety of addictive drugs, evidence is now beginning to accumulate regarding the role of executive deficits in nicotine use and addiction. In a cohort of childhood cancers survivors, attention deficits during childhood were found a significant predictor of ever smoking and current smoking behavior almost a decade later. This study also found evidence of executive dysfunction in adulthood, as deficits in memory and emotional regulation were observed in those who had ever tried smoking and current smokers [14]. In a large nonclinical adolescent sample symptoms associated with attention deficit hyperactivity disorder, a condition often linked to executive dysfunction [15], have been linked to the progression of smoking behavior and nicotine dependence. Hyperactive-impulsive symptoms were linked with progression from non-smoking to regular smoking and with progression from experimentation to regular smoking while hyperactive-impulsive symptoms and inattentive symptoms were associated with current nicotine dependence [16]. Moreover, adolescent smokers have demonstrated working memory deficits associated with an earlier age of smoking initiation and were

found to be independent of smoking recency [17]. Other research has linked impulsivity to the development of nicotine dependence among young adults [18] and related work found that scores on several domains of executive function predicted the frequency of tobacco use among college students [19]. The effects of cigarette consumption have also been observed across the lifespan, as a history of heavy smoking in a sample of healthy older adults was associated with deficits on the Wisconsin Card-Sorting Test, though other cognitive domains were unaffected [20].

Other research has found intensity of smoking was related to attention deficits and other executive abilities in middle and upper middle-aged adults [21]. Some research suggests the degree of nicotine dependence is particularly related to the ability to inhibit behaviours [22]. However, deficits in executive function have even been observed in light to moderate smokers [23].

Consistent with the above literature, studies suggest chronic cigarette use is also associated with altered structure [24-26] and function [13,27] of the prefrontal cortex.

Given the central role executive abilities play in drug addiction, it is conceivable that executive abilities may improve as a function of abstinence and/or treatment. However, research has yielded mixed results. Impairment of response inhibition among smokers continues across 3 months of abstinence [28] and hypoactivation in the frontal lobes has been observed among long term abstainers [29] suggesting executive deficits may persist among smokers. In contrast, other research maintains executive dysfunction associated with tobacco addiction may be more malleable. Spinella [12] found current smokers reported greater executive dysfunction than non-smokers and former smokers showed executive deficits between the two groups. Executive abilities were found better among an elderly sample of those who had quit smoking compared to active smokers [30] and partial recovery of cortical thinning among former smokers has been observed and was associated with length of abstinence [26]. Several studies have also suggested improved executive deficits may be predictive of abstinence following treatment. Some measures of impulsivity have been found predictive of abstinence among adolescents following completion of a program combining contingency management and cognitive behavioral therapy [31].

In a study using a highly dependent, low socioeconomic status sample enrolled in an intensive cognitive-behavioral program for nicotine dependence increased impulsiveness, delayed discounting and emotional regulation (smoking for reduction of negative affect) were among variables found to predict relapse [32]. In addition, studies successfully employing brain stimulation of the prefrontal cortex as treatment in nicotine dependent individuals further argues for the role of plasticity executive function across nicotine addiction and recovery [33,34].

The purpose of this study was to further examine changes in executive abilities as a function of tobacco cessation therapy. College students who expressed a desire to quit tobacco use were recruited to undergo Motivational Interviewing Therapy with or without the nicotine patch [34]. Executive function is complex construct as its neuropsychological study and assessment involve multiple distinct yet interrelated abilities and neuroanatomical substrates [2,4]. Previous studies have often examined a restricted range of executive abilities [22,23,31] or focused on a particular measurement approach (performance base versus self-report measures) [12,18], though the two approaches may be assessing different constructs [35] and possess

differential sensitivity to deficits [19,36,37]. The current study assessed executive abilities using multiple formats and across a broad range of executive abilities. Participants were administered the Frontal Systems Behavioral Scale (FrSBe) [38], a self-report measure designed to assess behaviors associated with damage to the frontal lobes across three domains: Apathy, Disinhibition and Executive Function and The Delis-Kaplan Executive Function System (D-KEFS) [39] which includes multiple performance based tasks. Tobacco dependence was measured via the Fagerstrom Test of Nicotine Dependence (FTND) [40]. Most studies of executive deficits and nicotine addiction have employed cross sectional research designs [12,29,30] or measured executive abilities initially and related them to subsequent treatment attrition or outcomes [31,32]. This study was relatively unique in that it assessed executive abilities in the same participants prior to treatment and approximately one and a half months after the initiation of treatment. Given that repeated administration of executive measures across time might be amenable to practice effects or other artifacts of repeated assessment, this study included a group of non-smokers who were administered the same battery of measures across a similar time span. It was hypothesized that executive abilities would increase in participants who underwent tobacco cessation therapy particularly in domains related to inhibition and impulsivity given the impact on these executive measures in previous studies [31,41].

## Materials and Method

### Participants

Twenty six individuals initially expressed interest in participating in a tobacco cessation therapy. Nine participants (35%) were tested prior to treatment, but did not complete the study because they did not pursue treatment [5], discontinued treatment following a single intake appointment [3] or withdrew from the university [1] leaving seventeen participants who were tested before and after engaging in tobacco cessation therapy. Twenty three non-smoking participants were recruited for this study; four participants were not tested at the second time point for unknown reasons.

### Measures

**Demographics and drug use questionnaire:** A demographics questionnaire asked participants questions regarding their sex, ethnicity, age and history of head injuries. Participants were also asked about their frequency of use of alcohol, tobacco products and other drugs.

The seventeen participants that were tested before and after engaging in tobacco cessation therapy were primarily female (53%) and White (82%), with mean age of 21.41 (SD=3.48). The nineteen non-smoking participants were primarily female (79%), White (74%) or African American (21%), with mean age of 19.63 (SD=1.57). Tobacco cessation participants did not significantly differ from the non-smoking participants on these demographic measures. In addition, no differences were observed between participants who completed tobacco cessation therapy and those who did not on demographic measures and tobacco addiction severity.

The number of days between test sessions did not differ between the tobacco cessation group (mean=51.23, SD=13.74) and non-smokers (mean=45.36, SD=8.09). The number of daily cigarette smokers decreased from 14 (82%) to 4 (23%) and the number who reported cigarette use within the last 30 days increased from 2 (12%) to 10

(60%) between test sessions. At the initial testing session two tobacco cessation participants reported being daily users of smokeless tobacco products and after treatment both reported use within the last 30 days. No tobacco cessation participants reported daily use of cigars at either time point while cigar use within the last 30 days was reported by 5 participants prior to treatment and 6 post treatment. At the initial testing session the majority of participants undergoing tobacco cessation therapy (82%) and non-smokers (58%) reported drinking alcohol in the last 30 days. No participants reported drinking alcohol on a daily basis. Three tobacco cessation participants (18%) and four non-smoking participants (21%) reported using drugs other than alcohol or tobacco within the last 30 days and two tobacco cessation participants and one non-smoking participant reported daily marijuana use at both test times.

### Nicotine dependence

The six items Fagerstrom Test of Nicotine Dependence (FTND) was used to assess participant's level of nicotine dependence [40]. The internal consistency estimate for the FTND among smokers in this sample was similar between test sessions and averaged 0.71 which is consistent with previous research using this measure [42].

### Executive function

The Frontal Systems Behavioral Scale (FrSBe) [38] was used to assess everyday behaviors associated with functions of the prefrontal cortex. This 46 item measure asks participants to rate themselves on the frequency of performing certain behaviors using a 5 point Likert scale (ranging from almost never to almost always). The FrSBe contains three subscales: Apathy (poor initiation, reduced drive and interest); Disinhibition (restlessness risk taking, socially inappropriate behavior) and Executive Dysfunction (difficulty with learning, mental flexibility and working memory). Previous research has indicated the subscales of this measure may be differentially sensitive to tobacco use [12], therefore this study focused on the subscales rather than the FrSBe total score. For statistical analysis all scores were converted to T-scores corrected for age, education and gender with a mean score of 50 and standard deviation of 10 according to the FrSBe Administration Manual [38]. Higher scores on this measure are indicative of poorer executive function. The internal consistency estimates for the FrSBe subscales for tobacco cessation and non-smoking group combined prior to treatment (Apathy=0.76, Disinhibition=0.67, Executive Dysfunction=0.85) were similar to those following treatment (Apathy=0.74, Disinhibition=0.82, Executive Dysfunction=0.83) and similar to those previously reported [38].

The Delis-Kaplan Executive Function System (D-KEFS) includes a set of nine performance based tasks designed to measure component processes of executive function [39]. Most D-KEFS tasks are derived from frequently used experimental and clinical measures, augmented by increased processing demands and switching conditions [3,39]. For most measures raw scores were converted to age-scaled scores.

Due to the large number of tasks and potential dependent measures associated with the D-KEFS three composite scores were derived and analyzed from the D-KEFS based on the results of two previously conducted factor analyses of the D-KEFS, both of which yielded similar results and composite scores which were both theoretically related and significantly correlated [19,43]. The four D-KEFS tasks administered for this study were the Sorting Test, Color-Word

Interference Test, Trail Making Test and Twenty Questions Test and have been extensively described elsewhere [2,39].

The first factor, labeled Conceptual Flexibility, was anchored by three Sorting Tests: Free Sort, Free Sort Description and Sort Recognition. The second factor, labeled Inhibition, emerged from the Trail Making Test, Number-Letter Switching and two measures on the Color-Word Interference Test; Completion Times Inhibition, Completion Times Inhibition/Switching. The third factor emerged from the Total Weighted Achievement Score and Total Questions Asked on the Twenty Questions Test was labeled Monitoring.

### Procedures and tobacco cessation

This study was approved by the Institutional Review Board at Indiana University of Pennsylvania. Participants in the tobacco cessation program were recruited through one of two mechanisms: advertisements placed across campus (53%) and via a research participation system for students taking an Introductory Psychology Course (47%). In both cases participants were invited to be part of a research project examining the relationship between tobacco cessation therapy and cognitive abilities. Participants were told that they must be interested in tobacco cessation, above 18 years of age, have English as their primary language and not have had a head injury that resulted in a concussion or loss of consciousness within the last 3 months.

At the initial testing session, details of the project were explained to participants and they were asked to provide informed consent. Participants were told that the research component of this study would involve two testing sessions, the current one and a second approximately 2 months later. At both testing sessions participants completed a demographics questionnaire with additional drug use frequency questions, the FTND and FrSBe and then administered the D-KEFS tasks in the order described above.

After the initial testing session participants were asked to make an appointment to begin tobacco cessation therapy within 2 weeks to discuss what type of treatment would be best for them. Tobacco cessation treatment was conducted by the licensed addictions counselor at the university's health and wellness services. The initial meeting with participants was 30-45 minutes followed by 15-30 min weekly appointments for as long as participants desired. Tobacco cessation treatment was cost free and emphasized Motivational Interviewing techniques, which stressed building commitment to behavioral change and decreasing ambivalence in making change as well as the option of receiving the Nicotine Replacement Patch containing 14 patches/box (Equate, 14 or 21 mg based on treatment personnel recommendation). Participants who were recruited via posted advertisements received a \$20 gift card to the campus bookstore and those recruited through research participation system received 2 research participation credits towards the research requirement for their Introductory Psychology course for each test session.

The non-smoking group was recruited only through the research participation system and was awarded 2 research participation credits towards the research requirement for their Introductory Psychology course for each test session. These participants were told the purpose of this study was to examine the effects of neuropsychological testing across time among those who are non-tobacco users and those undergoing Tobacco Cessation Therapy. All procedures were the same for these non-smoking participants with the exception of tobacco cessation therapy. Statistical analysis Chi square and independent sample t-tests were used to compare the tobacco cessation and non-

smoking groups on gender, age, ethnicity, executive function scores and number of days between test sessions. Analysis of covariance (ANCOVA) was used to compare differences in executive function at the second test session between tobacco cessation participants and non-smoking participants using pretest executive function scores as a covariate. Controlling for pretest scores is particularly important given previous research has found differences in executive function between smokers and non-smokers [12,19] and this procedure may be advantageous with small samples when random assignment is not possible [44,45]. All variables were tested for normality, multicollinearity, homogeneity of regression slopes, homogeneity of variance, linearity, reliability of covariates, homoscedasticity and for the presence of outliers. Post hoc analyses were conducted using a paired-sample t-test between pretest and posttest executive function measures for each treatment. The effectiveness of tobacco cessation therapy was assessed using a paired-sample t-test of FTND scores before and after treatment.

## Results

### Tobacco cessation

Among those undergoing tobacco cessation therapy one participant elected not to receive the nicotine patch and another discontinued after reporting an initial negative skin reaction. The mean number of boxes of nicotine patches supplied to participants was 2.63 (SD=1.50). Participants attended an average of 4.18 (SD=2.24) treatment sessions and remained in treatment for an average of 33.35 days (SD=17.36). Tobacco cessation participants had higher FTND scores before treatment (M=3.71, SD=2.64) compared to after treatment (M=0.88, SD=1.73), a statistically significant decrease of 2.82, 95% CI (1.51, 4.14),  $t(16)=4.56$ ,  $p<0.001$ ,  $d=1.10$ .

### Differences in executive function between smokers and non-smokers

Cigarette smokers, prior to tobacco cessation therapy, did not significantly differ from non-smokers on measures of executive function, except for FrSBe Apathy scores. Smokers FrSBe Apathy scores (58.00, SD=12.72) were significantly higher than non-smokers (47.47 SD=10.55), a statistically significant difference of 10.53, 95% CI (2.64, 18.41),  $t(34)=2.71$ ,  $p=0.01$ ,  $d=0.90$ .

### Differences in FrSBe scores following tobacco cessation

An ANCOVA was conducted to compare differences in FrSBe Disinhibition posttest scores between tobacco cessation participants and non-smoking participants after controlling for pretest FrSBe Disinhibition scores. All assumptions for this analysis were met. There was a linear relationship between pre- and post- test Disinhibition scores between groups, based on scatterplot visual inspection. There was homogeneity of regression slopes as the interaction term was not statistically significant,  $F(1,32)=1.32$ ,  $p=0.26$ . Standardized residuals for the interventions and for the overall model were normally distributed, as assessed by Shapiro-Wilk's test ( $p>0.05$ ). There was homoscedasticity and homogeneity of variances, as assessed by visual inspection of a scatterplot and Levene's test of homogeneity of variance ( $p=0.38$ ), respectively. There were no outliers in the data, as assessed by no cases with standardized residuals greater than  $\pm 3$  standard deviations. After adjustment for pretest FrSBe Disinhibition scores, there was a statistically significant difference in posttest FrSBe

Disinhibition scores,  $F(1,33)=10.33$ ,  $p=0.003$ , partial  $\eta^2=0.238$ . Post hoc analysis using a paired-sample t-test revealed participants undergoing tobacco cessation therapy showed a decrease in FrSBe Disinhibition scores between the pretest (M=55.65, SD=11.34) and posttest (M=50.35, SD=11.48), a statistically significant mean decrease of 5.29, 95% CI (1.82,8.77),  $t(16)=3.23$ ,  $p=0.005$ ,  $d=0.78$ . There was no significant difference for non-smokers on FrSBe Disinhibition scores between the pretest (M=50.58, SD=12.48) and posttest (M=53.47, SD=15.44).

An ANCOVA comparing differences in FrSBe Apathy posttest scores between tobacco cessation participants and non-smoking participants after controlling for pretest FrSBe Apathy scores met all assumptions for this analysis; however, showed no significant differences. A similar analysis examining FrSBe Executive Dysfunction scores failed to meet the homogeneity of regression slopes assumption of ANCOVA.

### Differences in D-KEFS scores following tobacco cessation

ANCOVAs were conducted to compare differences in the three D-KEFS composite posttest scores between tobacco cessation participants and non-smoking participants after controlling for each of the D-KEFS pretest composite scores. Concept flexibility, Inhibition and Monitoring Composite variables met all assumptions for analysis, though none of these comparisons yielded significant results.

## Discussion

The results of this study partially support the hypothesis that executive abilities, particularly within the domain of inhibition and impulsivity, would increase in participants who underwent tobacco cessation therapy. After controlling for pretest FrSBe Disinhibition subscale scores significant differences emerged between tobacco cessation participants and non-smoking controls in posttest Disinhibition scores. Post hoc analyses revealed a significant improvement in FrSBe Disinhibition scores among tobacco cessation participants, but no change among non-smokers. These longitudinal results are consistent with previous cross-sectional findings showing current smokers possessed greater executive dysfunction on the FrSBe than former smokers, who in turn scored greater than non-smokers [12] suggesting tobacco cessation is associated with an improved ability to inhibit ones impulses and behavior. In Spinella's study length of abstinence was unknown as was the participant's path to tobacco cessation. In this study it is likely that participation in a brief tobacco cessation program produced the reduction in self-reported disinhibited behavior, as no changes in FrSBe Disinhibition subscores were observed in the non-smoking control group suggesting this finding was not the result of repeated testing or the passage of time. In addition, consistent with previous research the use of Motivational Interviewing Therapy and the nicotine patch [46,47] yielded short term decreases in tobacco dependence in this study. The use of drugs, other than nicotine, by participants in this study, was relatively stable across test sessions and similar between tobacco cessation and non-smoking participants. It is possible that neuroplastic changes within the prefrontal cortex underlie these results [26], but other explanations such as changes in withdrawal status and other related lifestyle changes cannot be ruled out.

In contrast, the performance-based D-KEFS composite measure of Inhibition did not significantly change following tobacco cessation therapy. The finding that self-reported, but not performance-based,

changes in executive abilities were observed in this study is consistent with other research suggesting self-report measures may be more sensitive to differences in executive deficits among adolescent drug users [19] substance dependent populations [36,37] and other clinical populations [35]. Growing evidence suggests performance-based and self-report measures of executive functioning may be tapping into different constructs as the two approaches do not often yield significant correlations and those correlations are often small. Therefore, it has been hypothesized that each captures a different level of cognitive analysis with performance-based tasks assessing cognitive efficiency and self-ratings measures being indicative of successful pursuit of goals [35]. This interpretation is consistent with the general usage of performance-based measures to assess executive function among clinical populations by applying standardized procedures and the use of self-report measures to gauge difficulties individuals have completing daily tasks and supports the view that these approaches should not be taken as providing synonymous information.

This study is consistent with other research suggesting a greater sensitivity of the FrSBe Disinhibition subscale among drug users including cigarette smokers. Spinella [12] found the Disinhibition subscale most predictive of executive deficits among a variety of drugs and poly-substance users and the disinhibition subscale was significantly related to multiple indices of smoking (packs-years, cigars smoked per week, years of smoking, proportion of life smoking and attempts to quit smoking) when the other FrSBe subscales were not. Although, based on a small sample, using the Family Rating Form of the FrSBe, family members of heroin addicts undergoing methadone maintenance therapy reported observing significant changes only on the FrSBe Disinhibition scale following 3 months of treatment [6].

There are several possible reasons why the Disinhibition subscale may represent a more sensitive measure of executive deficits. This scale is believed to measure problems with inhibitory control and represent an inability to appropriately inhibit actions or behavior which, may manifest as impulsive, hyperactive and socially inappropriate behavior [38]. Disinhibited behaviors are ones that are typically observable across a variety of situations and also might readily elicit feedback from others. In addition, the immediate consequences of some disinhibited behavior, such as getting caught shoplifting, may be more acutely problematic and thus more memorable than other executive deficits. In contrast, the behaviors associated with the apathy subscale, such as psychomotor retardation, loss of drive, anergia and anhedonia, are less readily observable by others and may be less likely to draw one's own attention unless deficits are significant. In addition, some items on this subscale, such as those related to incontinence, may be applicable to only certain individuals and age groups. The questions on the Executive Dysfunction Subscale address a broad set of behaviors such as attention, working memory, planning and monitoring. Given that participants may be impaired across some, but not all of these domains, it is possible that significant impairment on this subscale may appear only when deficits are significant enough to cross domains or yield substantial functional impairment or impairment which garners the attention of others. Moreover, while there is significant overlap between areas of the prefrontal cortex and various executive abilities, measures of executive function rarely access a single ability or brain region. The Disinhibition subscale has been suggested to largely measure functions linked to the orbitofrontal cortex [12,48], a structure that has been implicated in tobacco dependence [49,50], suggesting the Disinhibition scale may be more sensitive because it is revealing fundamental deficits related to tobacco dependence.

In contrast to research suggesting greater sensitivity of FrSBe Disinhibition subscale to smoking behavior, in these study only scores on the Apathy subscale differed between smokers and non-smokers prior to tobacco cessation therapy. Previous research has shown that current and daily smokers show greater impairment on all three FrSBe subscales [12,19,51]. However, the present results may be related to specific characteristics of this sample as a previous cross cultural study reported that Chinese smokers scored significantly higher on all subscales of the FrSBe and the FTND compared to Australian smokers, though they concluded impairments on the FrSBe were not the result of differences in the degree of nicotine dependence [51]. Moreover, studies showing impairment across all 3 subscales of the FrSBe came from older community samples [12,51] while only FrSBe Apathy scores were related to nicotine dependence in a younger college student sample of mildly dependent smokers [19].

A major limitation of this research is its small sample size, which was the result of a loss of support for the tobacco cessation program being evaluated thus curtailing further data collection. In addition to restricting the study's overall generalizability, the small sample size of this study did not allow for potentially meaningful comparisons to be made such as examining differences in executive function between those who completed and failed to complete treatment. However, the consistency of these results with other research employing different methods [12] supports the value of this project to the existing literature. Several additional factors may limit the generalizability of these results. Participants were recruited for this study if they expressed an interest in tobacco cessation rather than employing an initial tobacco dependence screen and as a result the degree of tobacco dependence reported by participants was generally low. In addition, the tobacco cessation therapy in this study was highly individualized and variable in its nature and length. While these factors may limit the overall generalizability of these findings it can be argued that they are of high ecological validity or they represent the characteristics of individual's seeking and receiving tobacco cessation therapy within a university setting [46,52,53]. The extent to which these findings might generalize to non-college settings is unclear given the relationship between executive function and education level [38]. Other limitations of this study include a lack of explicit attention to participants smoking recency and withdrawal status, use of a single short-term posttest evaluation and reliance on self-report measurement of drug dependence [54].

Despite decreased cigarette use among college students over the past decade and a half and lower levels of cigarette smoking among college students compared to non-college peers cigarette use has been acknowledged as a problem by the majority of university health center directors and many colleges do not offer tobacco cessation programs or have programs in which participation is low [55]. A large proportion of college students will attempt to quit smoking, but only a minority will be successful [56]. An understanding of how executive abilities change as a function of treatment will likely be an important component of improving tobacco cessation programs.

## Conclusion

This study found improvement in self-reported disinhibition following successful short-term tobacco cessation therapy and suggests that treatment yields changes that might further enhance an individual's ability to resist impulses to relapse and perhaps improve the likelihood of further abstinence. Moreover, this study highlights that executive function should not be considered a unitary entity but

one that is vulnerable to be defined by the measures and measurement approaches used in its assessment.

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