Available online at www.sciencedirect.com
ScienceDirect
Addictive Behaviors 32 (2007) 765–783
ADDICTIVE BEHAVIORS

The underlying role of aggressivity in the relation between executive functioning and alcohol consumption

Peter R. Giancola *

Department of Psychology, University of Kentucky, 115 Kastle Hall, Lexington, KY 40506-0044, United States

Abstract

The research literature on the relation between cognitive functioning and alcohol consumption is inconsistent and difficult to interpret. The purpose of this study was to test a causal model that might help reconcile some of these conflicts. The model specifies that aggressivity is an important intermediary mechanism underlying the relation between executive functioning (EF) and alcohol consumption. Participants were 310 (152 men and 158 women) healthy social drinkers between 21 and 35 years of age tested in a laboratory setting. EF was measured with a battery of neuropsychological tests. Aggressivity and alcohol consumption (as well as cigarette and drug use frequency) were measured with self-report and interview formats. Aggressivity played a mechanistic role in the relation between EF and alcohol/drug use for men but not for women. Women evinced some unexpected positive relations between EF and alcohol use. This study serves as a first step in trying to reconcile previous inconsistent findings regarding the relation between cognitive functioning and alcohol use by demonstrating that a better understanding of this relation involves considering aggressivity as an intermediary variable.

Keywords: Executive functioning; Aggression; Alcohol use

1. Introduction

Alcoholics, as well as those with other substance use disorders, are characterized by deficits in cognitive functioning (reviewed in Evert & Oscar-Berman, 1995; Fals-Stewart, Schafer, Lucente, Fustine, & Brown, 1994). These persons exhibit cognitive deficits in a wide variety of areas including overall

* Tel.: +1 859 257 4502; fax: +1 859 323 1979.
E-mail address: peter@uky.edu.

0306-4603/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.addbeh.2006.06.015

intellectual capacity (Brown, Tapert, Granholm, & Delis, 2000), language competence (Tarter, Mezzich, Hsieh, & Parks, 1995), academic achievement (Moss, Kirisci, Gordon, & Tarter, 1994), attention (Tapert & Brown, 1999), decision making (Stout, Rock, Campbell, Busemeyer, & Finn, 2005), verbal skills (Beatty, Tivis, Stott, Nixon, & Parsons, 2000), mathematical abilities (O'Malley, Adamse, Heaton, & Gawin, 1992), visuospatial abilities (Tapert & Brown, 1999), cognitive efficiency (Nixon, Tivis, & Parsons, 1995), retrieval of verbal and nonverbal information (Brown et al., 2000), perceptual-motor skills (Tivis, Beatty, Nixon, & Parsons, 1995), as well as long- and short-term memory (Selby & Azrin, 1998).

1.1. Executive functioning

In addition to these deficiencies, one of the most consistent and pronounced cognitive deficits seen in alcoholics and drug abusers is a problem with executive functioning (EF; reviewed in Giancola & Moss, 1998; Lyvers, 2000). EF is defined as a higher-order cognitive construct involved in the planning, initiation, and regulation of goal-directed behavior (Luria, 1980; Milner, 1995). The cognitive abilities subsumed under the rubric of EF include attentional capacity, strategic goal planning, problem-solving, abstract reasoning, cognitive flexibility, hypothesis generation, temporal response sequencing, as well as the ability to organize and adaptively utilize information contained in working memory (Milner & Petrides, 1984; Stuss & Benson, 1984). It has been argued that the prefrontal cortex represents the primary neural substrate that subserves EF (Fuster, 1989; Milner & Petrides, 1984).

1.2. Executive functioning and alcohol use

Alcoholics have been shown to be deficient in a wide array of EF abilities such as problem solving, attentional capacity, verbal fluency, cognitive flexibility, abstract reasoning, information sequencing, hypothesis generation, and working memory (e.g., Beatty et al., 2000; Rosselli & Ardila, 1996; Smith & Oscar-Berman, 1992; Sullivan, Rosenbloom, & Pfefferbaum, 2000; Tapert & Brown, 1999). However, it is important to note that the relation between low EF and alcohol consumption is not restricted to alcoholics. Low EF has also been found to be related to increased alcohol consumption in children of alcoholics (e.g., Aytaclar, Tarter, Kirisci, & Lu, 1999; Peterson, Finn, & Pihl, 1992). Furthermore, there is a large literature demonstrating that EF is inversely related to social drinking (Arbuckle, Chaikelson, & Pushkar Gold, 1994; Hannon, Day, Butler, Larson, & Casey, 1983; Hartley, Elsabagh, & File, 2004; Parker & Noble, 1977; Parker, Parker, & Harford, 1991; Waugh, Jackson, Fox, Hawke, & Tuck, 1989; Williams & Skinner, 1990). Moreover, EF has also been found to be related to an earlier age of onset of drinking, an increased frequency of intoxication and alcohol use problems (Deckel, Bauer, & Hesselbrock, 1995), and greater negative consequences associated with alcohol consumption (Giancola, Zeichner, Yarnell, & Dickson, 1996), in social drinkers, as well as a longer drinking history in alcoholics (Tarter & Parsons, 1971).

Given the well-known role of EF in the regulation of behavior (Luria, 1980; Milner, 1995), it has been theorized that executive deficits contribute to increased alcohol use as a result of poor cognitive regulation of behavior (Deckel & Hesselbrock, 1996; Peterson & Pihl, 1991). A variation of this hypothesis is present in a significant number of influential neurocognitive theories of alcoholism (Evert & Oscar-Berman, 1995; Finn, 2002; Giancola & Tarter, 1999; Lyvers, 2000; Nixon, 1999; Pihl, Peterson, & Finn, 1990a; Sayette, 1993; Steele & Josephs, 1990; Tarter et al., 1999). Although these theories all posit

different cognitive mechanisms (e.g., working memory, cognitive efficiency, abstract reasoning, information appraisal, attention allocation, problem-solving, etc.), they all contend that dysfunction in these mechanisms manifests itself in the form of impaired behavioral control which then increases the probability of excessive drug and alcohol consumption.

However on balance, other research suggests no, or very limited, cognitive problems in alcoholics (e.g., Eckardt, Stapleton, Rawlings, Davis, & Grodin, 1995; Moss et al., 1994) or children of alcoholics (e.g., Alterman & Hall, 1989; Alterman, Searles, & Hall, 1989; Bates & Pandina, 1992; Hesselbrock, Stabenau, & Hesselbrock, 1985; Sher, Walitzer, Wood, & Brent, 1991). The literature focusing on social drinkers also contains a significant number of studies suggesting no relation between cognitive functioning and alcohol consumption (e.g., Alterman & Hall, 1989; Bates & Tracy, 1990; Carey & Maisto, 1987; Emmerson, Dustman, Heil, & Shearer, 1988; Hannon et al., 1985; Parsons & Fabian, 1982; Sinha, Parsons, & Glenn, 1989). Stirring the waters even further are reports that cognitive functioning and alcohol consumption are positively related (Elsabagh, Hartley, Randall, Seth, & File, 2004; Hannon et al., 1983; Stampfer, Kang, Chen, Cherry, & Grodstein, 2005).

The reasons for these inconsistent findings are not entirely clear, however, methodological differences among studies have been critically reviewed (Pihl, Peterson, & Finn, 1990b). One noteworthy explanation for these discrepant data is that the cognitive deficits observed in alcoholics are etiologically more closely related to comorbid psychopathology, particularly, conditions denoting an aggressive disposition such as conduct disorder and antisocial personality disorder (reviewed in Giancola & Tarter, 1999; Pihl & Peterson, 1991). Evidence for this argument comes from studies showing that antisocial adult alcoholics have greater cognitive deficits than their non-antisocial alcoholic counterparts (Finn, Mazas, Justus, & Steinmetz, 2002; Malloy, Noel, Longabaugh, & Beattie, 1990) and that young men at high risk for alcoholism evince cognitive deficits but only if they also have a comorbid antisocial personality disorder (Gillen & Hesselbrock, 1992). Furthermore, adolescent females with a substance use disorder also show a wide array of cognitive deficits but again, only if they also have a co-occurring diagnosis of conduct disorder. Girls with a substance use disorder diagnosis alone do not seem to differ from controls on such cognitive measures (Giancola & Mezzich, 2000).

Given that EF is subserved by neurological substrates, deficits in this arena are presumed to manifest themselves early in life (Moffitt, 1993; Tarter & Vanyukov, 1994). Viewed from a developmental perspective, low EF is not likely to have a proximal or direct influence on alcohol use. Instead, its impact on drinking is more likely to be distal or indirect. In other words, it has been argued that EF's influence on alcohol use presumably "works through" other variables (Gillen & Hesselbrock, 1992; Pihl & Peterson, 1991).

1.3. The mediating role of aggressivity

Aggressivity is a very well established risk factor for drug and alcohol problems (Gillen & Hesselbrock, 1992; Sher & Trull, 1994). Compared with controls, alcoholics typically exhibit elevated levels of homicide (Salloum, Daley, Cornelius, Kirisci, & Thase, 1996), violence (Linnoila, DeJong, & Virkkunen, 1989), marital aggression (Murphy, Winters, O'Farrell, Fals-Stewart, & Murphy, 2005), hostility (Moss, 1989), property damage (Cordilia, 1985), theft (Hanlon, Nurco, Kinlock, & Duszynski, 1990), and other forms of criminal behavior (Bohman, Cloninger, Sigvardsson, & von Knorring, 1982; Phillips & Nixon, 1998). More importantly, from a developmental perspective, it can be argued that compared with EF, aggressivity has a more proximal or direct influence on alcohol use. In fact, a number

of recent studies have shown that aggressivity is one of the strongest and most reliable predictors (as well as correlates) of drug and alcohol use (Brook, Whiteman, Finch, & Cohen, 1995; Mâsse & Tremblay, 1997; Molina & Pelham, 2003; O'Donnell, Hawkins, & Abbott, 1995), an early age of onset of alcohol use (Hesselbrock et al., 1985; Windle, 1993), problem drinking (Pulkkinen & Pitkanen, 1994; Zuckerman, 1987), and a diagnosis of alcoholism (Biederman et al., 1997; Cloninger, Sigvardsson, & Bohman, 1988; Wood, Sher, & Erickson, 1995).

The developmental psychopathology literature indicates that low EF is an etiological precursor of aggressive behavior (Moffitt, 1993; Raine et al., 2005). Specifically, EF has been shown to be related to aggression (Seguin, Nagin, Assaad, & Tremblay, 2004) and delinquency (Lynam, Moffitt, & Stouthamer-Loeber, 1993) in adolescent boys as well as self-reports of violent and nonviolent conduct disorder symptoms in adolescent females with a substance use disorder (Giancola, Mezzich, & Tarter, 1998). Furthermore, low EF, measured at 10–12 years of age in boys at high risk for a substance use disorder, has been found to predict increased aggression at a 2-year follow-up (Giancola, Moss, Martin, Kirisci, & Tarter, 1996).

In addition to the above literature review, research has also demonstrated that EF, measured in 10- to 12-year-old boys with and without a family history of a substance use disorder, significantly predicted aggressivity and affiliations with delinquent peers at age 14 which, in turn, significantly predicted drug use at age 16 (Giancola & Parker, 2001). These data were later replicated in a cross-sectional sample of adolescent females with a substance use disorder (Giancola, Shoal, & Mezzich, 2001). It is noteworthy that the direct relation between EF and drug use was either absent or weak in both of these studies thus mirroring the inconsistent findings reviewed above in alcoholics, children of alcoholics, and social drinkers. However, the results of these two studies suggest that the inclusion of aggressivity as an intermediary variable in the relation between EF and alcohol consumption will play an important role in clarifying the conflicting data that has vexed these literatures.

Based on the above review, one can make the case that aggressivity may serve as an underlying mechanism for the relation between EF and alcohol/drug consumption. Given this, it is hypothesized that if a significant inverse relation between EF and alcohol consumption is present, it will be mediated by aggressivity (so long as the conditions for testing mediation are satisfied). However, if EF and alcohol consumption are not significantly related, EF will then be significantly related to aggressivity which, in turn, will be significantly related to drinking. If this hypothesis is upheld, it will help clarify the inconsistent findings reviewed above by demonstrating that aggressivity is a key mechanism in the relation between EF and alcohol consumption.

2. Method

2.1. Participants

Participants were 310 (152 men and 158 women) healthy social drinkers between 21 and 35 years of age (M=23.03; S.D.=2.85). They were recruited through advertisements placed in various newspapers in Lexington, Kentucky. Respondents were initially screened by telephone. Individuals reporting any past or present drug- or alcohol-related problems, serious head injuries, learning disabilities, or serious psychiatric symptomatology were excluded from participation. Respondents were screened for alcohol use problems using the *Short Michigan Alcoholism Screening Test* (SMAST; Selzer, Vinokur, & van

Rooijen, 1975). Any person scoring an "8" or more on the SMAST was excluded from participation. Anyone with a positive breath alcohol concentration (BrAC) reading or a positive urine drug test result (tested for cocaine, marijuana, morphine, amphetamines, benzodiazepines, and barbiturates) was also excluded. Two men had a positive BrAC and one woman had a positive drug test. These individuals were not assessed. They were given an opportunity to reschedule another appointment but they elected to not do so.

The sample consisted of 286 Caucasians, 23 African-Americans, and 1 Hispanic. Eighty-nine percent of the participants were never married, 31.3% had a high-school degree and were not pursuing further education, 43.9% had a high-school degree and were working on a bachelor's or an associate's degree, 21.6% had a bachelor's or an associate's degree, 1.9% had a graduate degree, and 1.3% did not graduate from high-school. Forty-eight percent of the sample supported themselves financially and earned approximately $18,500 per year; the remainder were supported by a parent or by a spouse. Participants received $50 at the completion of the study as compensation.

2.2. Selection of neuropsychological tests

As noted in the Introduction, current theories highlight the importance of EF as a key etiological contributor to dysregulated behaviors such as excessive drinking and antisociality (Lyvers, 2000; Moffitt, 1993; Tarter et al., 1999). The selection of the EF battery was based on functional and neuroanatomical considerations according to guidelines put forth by Diamond (1991). From a functional perspective, tests of EF were chosen to reflect a wide variety of skills encompassed by this construct such as attentional control, previewing ability, strategic goal planning, abstract reasoning, cognitive flexibility (set shifting), hypothesis generation, inhibition, and the ability to organize and adaptively utilize information contained in working memory. From a neuroanatomical perspective, tests of EF were selected on the basis of being generally accepted as measures of functions that are subserved primarily by the prefrontal cortex. The prefrontal cortex and its subcortical circuits are thought to be the primary neurological substrates that subserve EF (Fuster, 1995; Luria, 1980; Stuss & Alexander, 2000). There are extensive neuroimaging data with normals and ample neuropsychological evidence from patients with acquired brain lesions demonstrating that the EF tests selected for this investigation measure primarily prefrontal cortical functions (e.g., Casey et al., 1997; Demakis, 2003; Goel & Grafman, 1995; Karnath, Wallesch, & Zimmermann, 1991; Petrides, Alivisatos, Evans, & Meyer, 1993; Rezai et al., 1993; Sasaki, Gemba, Nambu, & Matsuzaki, 1993; Stuss, Floden, Alexander, & Katz, 2001). The following tests were all administered according to standard procedures.

2.2.1. Porteus maze test

Participants were required to navigate their way through eight mazes (Porteus, 1965). They were instructed to not lift their pencil from the paper until each maze was completed. The Impulsive Errors score (i.e., Qualitative Score) was used to index EF (Porteus, 1965). This type of error reflects a lack of foresight, poor judgment, difficulty learning from experience, as well as poor planning and organizational abilities (Crown, 1952; Porteus & Kepner, 1944).

2.2.2. Go/no-go task

Participants completed a computerized version of this task (Newman & Kosson, 1986). Participants were informed that a series of numbers were going to be presented, one at a time, in the center of a

computer screen. They were told that they had an opportunity to win money based on their performance on the task. Participants were informed that each time a number appeared on the screen they had to choose whether or not they were going to press the spacebar on the keyboard and that their choice would result in either winning or losing money. They were given no further instructions. Prior to beginning the task, $5.00 in quarters was placed on the table in front of the participant. The experimenter kept a large stack of quarters on his/her side of the table. Each time the participant won or lost a trial, the experimenter would respectively give or take away a quarter from the participant. Participants did not win or lose money if they made no response at all.

The task had a total of 85 trials. A total of 10 numbers were used. Five numbers were "winners" (37, 96, 78, 53, 29) and five were "losers" (43, 82, 64, 73, 31). The numbers were presented on the computer screen for 2 s with an intertrial interval of 1 s. The first five trials were all winning numbers (to establish a dominant response set) and the remainder of the trials were randomly ordered with no consecutive win or lose sequence exceeding three trials. Participants had to learn, by trial and error, when to respond and when to not respond. Trials were presented in eight continuous blocks of 10, excluding the first five. EF was indexed by the total errors of commission (i.e., pressing the spacebar when incorrect) for the last 40 trials of the task. Such errors reflect an inability to inhibit incorrect responding under circumstances involving sustained attention (Newman & Kosson, 1986).

2.2.3. Trails B of the trail making test

Participants were given a sheet of paper randomly arranged with the numbers "1" through "13" and the letters "A" through "L." They were told that they had to connect the numbers and letters in an alternating sequence (e.g., 1-A-2-B-3-C...) as quickly as possible using a pencil. If an error was made, the experimenter quickly informed the participant so that it could be corrected. Performance on this task was measured by the amount of time taken to complete all of the connections (Reitan, 1992). Success on this task requires good cognitive flexibility and set shifting skills in order to quickly and repeatedly alternate between two different tasks.

2.2.4. Stroop task

Participants were presented with three stimulus cards. For the first card, they were instructed to read a list of words (red, blue, green, yellow) printed in black ink as quickly as possible. For the second card, they were asked to name the color (red, blue, green, yellow) in which a series of "X"'s were printed as quickly as possible. These first two parts of the task respectively measure verbal and nonverbal perceptual processing speed. For the third card, participants reported the color of the ink in which words were printed as quickly as possible; however, the word names were incongruent with the colors in which they were printed. EF was indexed by the "interference score," derived by subtracting the response time of the second portion of the task (color naming) from the response time of the third portion of the task (incongruent color-word naming) (MacLeod, 1991). Poor performance on this task reflects an inability to inhibit the effects of a distracting stimulus as well as poor attentional skills (MacLeod, 1991; Perret, 1974).

2.2.5. Conditional associative learning test

Seven black squares (1 in. × 1 in.) were printed on a laminated 3 in. × 11 in. card and placed before the participant. Seven small lights were fixed, in a random arrangement, onto a 10 in. × 8 in. metal box which was placed anterior to the card. Participants were asked to learn the manner in which the squares and the

lights were associated. The experimenter illuminated the lights in a fixed random order and the participant's task was to point to the square that s/he believed was associated with the particular illuminated light. Participants learned the associations by trial and error based on feedback from the experimenter. The task ended when 17 consecutive correct responses were achieved or when 210 trials were exhausted. Performance was indexed by the number of errors committed. This test measures the ability to organize and utilize information contained in working memory (Petrides, 1985).

2.2.6. Tower of Hanoi

Participants were presented with a wooden platform mounted with three vertical rods. Five rings (differing in circumference) were stacked on the left-most rod (smaller rings were always stacked on top of a larger ring). Participants were instructed to reproduce the same stacking configuration of rings on the right-most rod by moving the rings according to the following three rules: (1) only one ring can be moved at a time; (2) a larger ring cannot be placed on a smaller ring; and (3) unless actively being moved, no ring can be removed from a rod. Three trials were conducted. The first involved four rings and the second and third involved all five. Performance was indexed by the number of moves taken to complete the first and third trials (Goel & Grafman, 1995). Scores from the second trial were not used because the test was so difficult that most participants could not solve the problem. This task measures strategic planning and the organization and use of information contained in working memory reflected as the ability to sequentially order a series of responses to achieve a particular goal (Goel & Grafman, 1995).

2.2.7. Wisconsin card sorting test

A computerized version of this task was administered (Heaton, 1993). Participants were presented with four sample "cards" at the top of the screen. The cards depicted between one and four stimulus shapes (i.e., circle, triangle, cross, and square) that were printed in one of four colors (i.e., red, blue, yellow, and green). At the bottom of the screen was a "deck" of 128 cards each printed with different combinations of these shapes and colors. Participants were asked to match each card from the deck to one of the sample cards. The cards could be matched according to their similarity in color, shape, or number of stimuli. However, participants were not informed of the matching principles. Each time 10 consecutive correct matches were achieved, the computer changed the matching principle without notifying the participants. The test proceeded until six sorting categories were completed or until all 128 cards were used. Performance on this task was indexed by the number of errors committed. Success on this task requires the ability to abandon a previous sorting principle and then generate and test new hypotheses about other solutions thus capitalizing on cognitive flexibility and set shifting skills.

2.3. Data reduction

In accordance with the results of a previously published confirmatory factor analysis on these data (Giancola, 2004), scores from the neuropsychological tests were *z*-transformed and then summed to create an EF variable. The internal consistency for this aggregate score is 0.54. Higher scores indicate better performance. The moderate internal consistency coefficient for the EF score is consistent with previous research. Factors contributing to this level of magnitude include the fact that (1) EF tests assess different processes (i.e., planning, organization, set-shifting, etc.) thus reflecting the multifaceted structure of EF; (2) each test also measures different non-EF components; and (3) the tests use different facets of behavior for their scoring metrics (e.g., time, accuracy, number of correct responses, etc.). Nevertheless,

despite these disparities, tests of EF still tend to form cohesive wholes thus highlighting the cohesive, yet multifaceted, nature of the EF construct. The sample reported in this article is the same as that reported in Giancola (2004).

2.4. Aggressivity

2.4.1. The Buss–Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992) was used to measure aggressivity

The BPAQ is a well-known 29-item inventory with four subscales (i.e., Physical Aggression, Verbal Aggression, Anger, and Hostility). The BPAQ is scored on a 5-point Likert scale and has been shown to have excellent psychometric properties (Buss & Perry, 1992; Tremblay & Ewart, 2005; Williams, Boyd, Cascardi, & Poythress, 1996). Cronbach's alpha for the current sample was 0.84. Previous research has shown that physical aggressivity is more strongly related to drug and alcohol use than less severe forms of delinquent and disruptive behaviors (Giancola et al., 1998). As such, aggressivity in this study was indexed by participants' scores on the Physical Aggression subscale.

2.5. Alcohol and drug use

2.5.1. Daily alcohol consumption

We assessed mean alcohol consumption over the past year using a standard quantity–frequency measure (Cahalan, Cisin, & Crossley, 1969). The following variables were assessed: (1) number of drinks per occasion; (2) number of drinking occasions per week; and (3) drinks per week. A "drink" was defined as a 1.5 oz shot of liquor, a 4 oz glass of wine, or a 12 oz beer.

2.5.2. Dysregulated drinking

Dysregulated drinking was assessed using the *Alcohol Dependence Scale* (ADS; Skinner & Allen, 1982), a 25-item inventory that measures severity of alcohol consumption across several domains including behavioral control (e.g., blackouts, gulping drinks, stumbling), obsessive–compulsive drinking (e.g., drinking throughout the day, always having a bottle handy), as well as psycho-perceptual and psychophysiological withdrawal (e.g., hallucinations, hangovers, having the "shakes"). The ADS is well-validated and has sound psychometric properties (Skinner & Allen, 1982). In the present sample, we obtained an alpha reliability coefficient of 0.81.

2.5.3. Drug use frequency

In order to broaden the scope of our investigation, participants completed a *Drug Use Questionnaire* (DUQ; Tarter, 1989) to determine their weekly frequency of licit and illicit past-year substance use. The DUQ separates drugs into 10 categories: (1) marijuana or hashish; (2) cocaine or crack; (3) stimulants (e.g., amphetamines, methamphetamine, etc.); (4) over-the-counter stimulants (e.g., diet pills, caffeine pills, etc.); (5) sedatives or hypnotics (e.g., barbiturates, benzodiazepines, sleeping pills, etc.); (6) over-the-counter sedatives (e.g., cough syrup—to get high); (7) opioids (e.g., heroin, morphine, other pain killers, etc.); (8) hallucinogens (e.g., LSD, ecstasy, PCP, etc.); (9) inhalants (e.g., glue, gasoline, cleaning fluid, etc.); and (10) tobacco products (predominantly cigarettes). As opposed to alcohol use, measuring quantity of drug use is a formidable task prone to much error inasmuch as most individuals have great difficulty reliably and accurately reporting the amount of different drugs used on different occasions. As

such, in order to maintain the integrity of our data, we derived two measures from this inventory: (1) cigarettes smoked per week (item #10) and (2) weekly drug use frequency (sum of items 1–9). We separated cigarettes from other substances given that their use is significantly easier to quantify.

2.6. Procedure

Upon arrival to the laboratory, all participants provided informed consent. Demographic and alcohol/drug use data were then collected. Participants then completed the neuropsychological tests. The tests were administered in a fixed order across participants and took approximately 1.5 h to complete. Participants were given a 10-min break after the first hour of testing. After completing the neuropsychological tests, they completed the BPAQ.

3. Results

3.1. Demographic data

Gender differences were assessed using bi-directional *t*-tests. Results indicated that, compared with women, men had higher SMAST scores, got drunk at an earlier age, began drinking regularly at an earlier age, had more drinking occasions per week, consumed more drinks per occasion, consumed more drinks per week, consumed more cigarettes per week, reported more drug use per week, and had higher scores on the ADS and BPAQ. These data are presented in Table 1.

3.2. Correlations among the variables

Table 2 depicts correlations between the variables for men and women. The drinks per week variable is a composite of the drinking occasions per week variable and the number of drinks per occasion variable, thus clearly accounting for its high correlations with its constituent variables. Readers should keep this in mind when examining the results. Despite this overlap, we decided to utilize this variable because it represents a clear and easily understandable index of the quantity of alcohol consumed per week. This aspect of alcohol consumption topography is not provided by the other indicators.

3.3. Statistical analyses

The principal aim of this investigation was to determine whether previous conflicting findings regarding the relation between cognitive functioning and alcohol consumption can be reconciled by taking into account aggressivity as an underlying variable. The hypothesis to be tested is as follows: if a significant inverse relation between EF and alcohol consumption is present, it will be mediated (so long as the conditions for testing mediation are satisfied) by aggressivity; however, if EF and alcohol consumption are not significantly related, EF will then be significantly related to aggressivity which, in turn, will be significantly related to drinking. Either way, it is hypothesized that aggressivity will play an intermediary role in the EF-drinking relation.

Baron and Kenny (1986) noted that there are three conditions that must be satisfied in order for mediation to be tested: (a) the independent variable (EF) must be significantly related to the proposed

Table 1
Demographic data

Measure	Men		Women	
	M	S.D.	*M*	S.D.
Age	23.34	3.07	22.72	2.58
Years of education	15.92	2.02	16.31	2.00
Salary	$18.86K	$12.72K	$17.80K	$9.80K
Executive functioning [a]	0.00	1.00	−0.01	1.00
SMAST	1.93	2.85	0.36	1.46*
Age at first drink	15.22	2.61	15.70	2.50
Age when first drunk	15.90	2.45	16.57	2.51*
Age when regular drinking began	18.48	2.32	19.11	2.17*
Drinking occasions per week	2.36	1.37	1.73	1.18*
Drinks [b] per occasion	6.30	3.48	3.75	1.67*
Drinks [b] per week	15.75	12.91	6.78	6.35*
Cigarettes per week	4.32	4.22	3.43	4.17*
Drug use frequency per week	3.98	5.06	2.67	3.44*
ADS	32.95	5.42	30.88	4.17*
BPAQ	21.53	6.82	15.62	5.40*

SMAST = Short Michigan Alcoholism Screening Test. K = $1000.
ADS = Alcohol Dependence Scale; BPAQ = Buss–Perry Aggression Questionnaire.
[a] Data represented as *z*-scores.
[b] A drink is defined as approximately 12 g or 15 ml of absolute alcohol.
* $p < 0.05$.

Table 2
Correlations among the variables

	1	2	3	4	5	6	7	8
(1) Executive functioning		−0.33	−0.12	−0.20	−0.20	−0.09	−0.22	−0.24
		0.001	0.15	0.01	0.01	0.29	0.006	0.002
(2) Aggressivity	−0.24		0.25	0.21	0.28	0.20	0.28	0.35
	0.003		0.002	0.008	0.001	0.02	0.001	0.001
(3) Drinking occasions per week	−0.01	0.05		0.19	0.75	0.30	0.21	0.33
	0.88	0.57		0.02	0.001	0.001	0.01	0.001
(4) Drinks per occasion	0.28	−0.10	0.18		0.72	0.53	0.12	0.23
	0.001	0.24	0.03		0.001	0.001	0.14	0.003
(5) Drinks per week	0.16	−0.06	0.75	0.69		0.54	0.20	0.38
	0.04	0.48	0.001	0.001		0.001	0.01	0.001
(6) Dysregulated drinking (ADS)	0.12	0.08	0.37	0.41	0.48		0.01	0.37
	0.12	0.32	0.001	0.001	0.001		0.87	0.001
(7) Cigarettes per week	−0.06	0.14	0.17	0.15	0.20	0.15		0.41
	0.44	0.08	0.03	0.07	0.01	0.06		0.001
(8) Drug use frequency per week	−0.07	0.06	0.26	0.03	0.18	0.20	0.34	
	0.41	0.44	0.001	0.71	0.03	0.01	0.001	

Values above the diagonal represent men and those below the diagonal represent women. *P*-values are listed below the correlation coefficients.
ADS = Alcohol Dependence Scale.

mediator (aggressivity); (b) the independent variable must be significantly related to the dependent variable (alcohol/drug use); and (c) the mediator must be significantly related to the dependent variable. If these conditions are present, one can then test whether the influence of the independent variable on the dependent variable is substantially reduced following the inclusion of the mediator. If this is found to be the case, mediation is present. In accordance with our hypothesis, if EF was not significantly related to a particular dependent variable, we then proceeded to determine whether it was significantly related to aggressivity as well as determining whether aggressivity was significantly related to the dependent variable. All analyses were conducted using simple and multiple regression techniques.

3.3.1. Statistical control

Traditionally, variables such as age, education, general intelligence (IQ), and socioeconomic status (SES) have been statistically controlled in analyses examining the relation between cognitive functioning and alcohol consumption. However, Bates and Tracy (1990) astutely pointed out that controlling for such variables inappropriately excises variance that is intrinsic to cognitive functioning. From a practical perspective, it is impossible to draw a distinction between IQ and cognitive functioning. In other words, what aspect of IQ is not "cognitive?" The same logic applies to EF. Many components of IQ are intrinsic to EF (Duncan, Emslie, Williams, Johnson, & Freer, 1996) and controlling for these factors will wrongly remove variance that is fundamental to EF. Following this line of reasoning, Bates and Tracy (1990) also made the point that IQ has an impact on level of education as well as SES. Furthermore, whereas age is also clearly related to education and SES, its influence on these variables is certainly not causal, but instead moderated by IQ. Finally, level of education also strongly impacts SES. On the basis of these arguments, these variables were not controlled in this study.

3.3.2. Gender

Given that men generally exhibit more physical aggression compared with women and also tend to have higher rates of drug and alcohol use, we conducted the analyses separately for each gender.

3.3.3. Men

As can be seen in Table 2, the conditions for mediation were satisfied for the following variables: drinks per occasion, drinks per week, cigarettes per week, and weekly drug use frequency. Fig. 1 then goes on to show that, using Baron and Kenny's (1986) method, aggressivity successfully mediated the relation between EF and all of these dependent variables. The inclusion of aggressivity into each of the models respectively reduced the effect of EF on the dependent variables by 25%, 40%, 36%, and 42%. In addition to this method, others have further examined mediation effects by testing whether the magnitude of the reduction in the original relation is statistically significant when the mediator is added. The significance of the reductions caused by including aggressivity in the four above models was tested using a method described in MacKinnon, Krull, and Lockwood (2000) and Sobel (1986). Results indicated that the insertion of aggressivity significantly reduced the original relations ($Z<0.05$) in all cases except for the drinks per week variable. Nevertheless, it is clearly important to note that the addition of aggressivity still reduced the relation between EF and drinks per week by 40%. As for the variables that did not meet the conditions for mediation (drinking occasions per week and dysregulated drinking on the ADS), Fig. 1 clearly shows that EF was significantly related to aggressivity which was significantly related to both dependent variables.

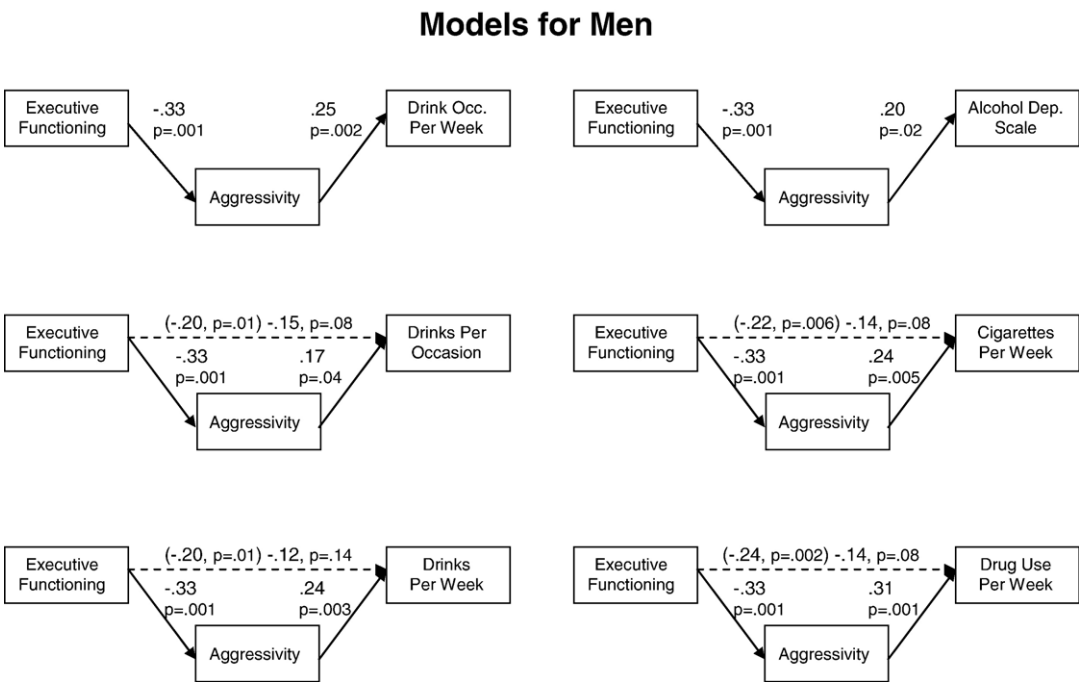

Fig. 1. Regression models depicting aggressivity as an intermediary variable between executive functioning and alcohol and drug use for men. Values in parentheses represent regression coefficients for the direct relation between executive functioning and the dependent variables. Values to the right of the parentheses represent regression coefficients following the addition of the aggressivity variable to the models.

3.3.4. Women

The necessary conditions for mediation were not met for any of the dependent variables for women (see Table 2). As can be seen in Table 2, EF was significantly related to aggressivity. However, aggressivity was not related to any of the dependent variables. Furthermore, although EF was significantly related to drinks per occasion and drinks per week (and nonsignificantly related to dysregulated drinking on the ADS), these associations were not in the predicted direction (i.e., higher EF was related to increased drinking). All other relations were not significant.

4. Discussion

Taken as a whole, our results suggest a possible, yet partial, explanation (at least for men) for the inconsistent findings often reported in the different literatures on cognitive functioning and alcohol consumption. Beginning with the results for men, only half of the possible direct relations between EF and the alcohol variables were statistically significant. These data are quite consistent with the inconsistent findings reported in the literature. However, when we consider aggressivity as an intermediary mechanism in the relation between EF and drinking, we see that all of the relations are now significant. More specifically, EF was significantly related to aggressivity which was significantly related to drinking occasions per week and dysregulated drinking on the ADS. Furthermore, aggressivity mediated the

effects of EF on drinks per occasion and drinks per week, thus respectively accounting for 25% and 40% of these original relations. The data for cigarette and drug use also indicate that aggressivity mediated the relation between EF and each of these variables. In fact, the introduction of aggressivity into the models reduced these relations by 36% and 42%, respectively. In summary, these data demonstrate an indirect relation between EF and alcohol/drug use, working through aggressivity, for men.

The findings for women are more complicated. Aggressivity did not function as an intermediary mechanism for any of the analyses. This may be due to men simply being more aggressive than women or that the consequences of aggression might be perceived as more serious for women. Another possibility is that there exist gender-specific pathways towards drug and alcohol use. Unfortunately, we do not have the appropriate measures in our data set to test these hypotheses. Women also evinced unexpected positive relations between EF and alcohol use suggesting that better EF is related to increased drinking. Specifically, EF was positively related to drinks per occasion, drinks per week, and dysregulated drinking. However its relation to dysregulated drinking was not significant (see Table 2). Although we would caution against over-interpreting unexpected and non-significant findings, it should be pointed out that some studies have reported a positive relation between light-moderate alcohol consumption (1–2 drinks per day) and cognitive functioning, particularly in women (Elsabagh et al., 2004; Galanis, et al., 2000; Kalmijn, van Boxtel, Verschuren, Jolles, & Launer, 2002; Stampfer et al., 2005). However, it is important to note that these studies were conducted on elderly samples which limits their explanatory applicability to the present investigation. Clearly, the positive relation between cognitive functioning and drinking in women requires further exploration. Given the limitations of our study in addressing the underlying nature of these unexpected findings, we base further interpretation on only the data provided by men.

From a developmental perspective, it is well known that, short of pre- or perinatal damage or later injury, many neuropsychological difficulties that are present at birth do not manifest themselves behaviorally until childhood (Moffitt, 1993; Spreen, Risser, & Edgell, 1995). These difficulties have been repeatedly shown to predict later disruptive and aggressive behaviors (Moffitt, 1993; Raine, 2005). It is postulated herein that low EF leads to poor cognitive regulation of behavior thus increasing the risk of exhibiting antisocial behavior, especially when bored, irritated, angered, or provoked. Specifically, impaired self-monitoring, abstract reasoning, and attentional skills may compromise the ability to correctly interpret potentially ambiguous social cues which may lead to misattributions in the perception of threat or hostility in conflict situations. Ineffectual hypothesis generation, poor concept formation, poor judgment, and cognitive inflexibility may undermine the ability to generate and implement appropriate alternative behavioral responses in irritating or anger provoking situations. Deficiencies in the above skills may also interfere with the capacity to fully consider and appreciate the potentially negative consequences of engaging in high risk behaviors. Inadequate planning, temporal sequencing, and organization skills may interfere with the ability to execute a series of responses in the proper order and manner to avoid potentially volatile social interactions and dangerous situations.

The above factors, along with attendant antisociality, can then progress to a number of negative outcomes such as affiliating with delinquent peers (Giancola & Parker, 2001; Lynam et al., 1993) who might introduce the individual to drug and alcohol use or simply encourage and exacerbate already existing use (Brook, & Newcomb, 1995; Chassin, Pillow, Curran, Molina, & Barrera, 1993; Giancola & Parker, 2001; Windle, 1990). This hypothesis is supported by a study showing that the relation between aggressivity and drug use is mediated by affiliations with delinquent peers (Giancola & Parker,

2001). As such, although cross-sectional, our data bear the assumption that aggressivity serves as an intermediary variable between cognitive functioning and excessive alcohol and drug use, at least for men.

Given past critiques of the methodological weaknesses in the literature on cognitive functioning and alcohol consumption (Parsons, 1986; Parsons & Nixon, 1998), it is important to note that we addressed many of these concerns in the present investigation. For example, participants were excluded from the study if they had a positive BrAC reading or a positive result on a urine drug screen. This reduced the chances that cognitive decrements might be due to acute alcohol or drug use. We also did not limit our analyses to only quantity–frequency measures of alcohol but also added a measure of dysregulated drinking as well as measures of cigarette and drug use. We are aware that these measures are relatively crude and that we only assessed drug use frequency. Nonetheless, the results are encouraging and are in need of further study. Furthermore, in previous studies, specific neuropsychological tests were selected for use because they had been shown to detect differences between alcoholics and controls. Rather than taking such an atheoretical approach, the selection of our neuropsychological battery was guided by current theories highlighting the key role of EF as an underlying cognitive mechanism of alcoholism and antisociality. Finally, this is one of the first investigations examining the relation between cognitive functioning and social drinking to have aggregated its measures of cognitive functioning. This is a significant advantage over previous studies in that it markedly reduced the risk of committing both Type I and Type II statistical errors.

Acknowledgement

This research was supported by Grant R01-AA-11691 from the National Institute on Alcohol Abuse and Alcoholism.

References

Alterman, A., & Hall, J. (1989). Effects of social drinking and familial alcoholism risk on cognitive functioning: Null findings. *Alcoholism, Clinical and Experimental Research*, *13*, 799−803.

Arbuckle, T., Chaikelson, J., & Pushkar Gold, D. (1994). Social drinking and cognitive functioning revisited: The role of intellectual endowment and psychological distress. *Journal of Studies on Alcohol*, *55*, 352−361.

Aytaclar, S., Tarter, R. E., Kirisci, L., & Lu, S. (1999). Association between hyperactivity and executive cognitive functioning in childhood and substance use in early adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, *38*, 172−178.

Baron, R., & Kenny, D. (1986). The moderator-mediator variable distinction in social psychology research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173−1182.

Bates, M., & Pandina, R. (1992). Familial alcoholism and premorbid cognitive deficit: A failure to replicate subtype differences. *Journal of Studies on Alcohol*, *53*, 320−327.

Bates, M. E., & Tracy, J. I. (1990). Cognitive functioning in young "social drinkers": Is there impairment to detect? *Journal of Abnormal Psychology*, *99*, 242−249.

Beatty, W., Tivis, R., Stott, H., Nixon, S., & Parsons, O. (2000). Neuropsychological deficits in sober alcoholics: Influences of chronicity and recent alcohol consumption. *Alcoholism, Clinical and Experimental Research*, *24*, 149−154.

Biederman, J., Wilens, T., Mick, E., Faraone, S., Weber, W., Curtis, S., et al. (1997). Is ADHD a risk factor for psychoactive substance use disorders? Findings from a four-year prospective follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*, 21−29.

Bohman, M., Cloninger, R., Sigvardsson, S., & von Knorring, A. (1982). Predisposition to petty criminality in Swedish adoptees. *Archives of General Psychiatry*, *39*, 1233−1241.

Brook, J., & Newcomb, M. (1995). Childhood aggression and unconventionality: Impact on later academic achievement, drug use, and workforce involvement. *Journal of General Psychology*, *156*, 393−410.

Brook, J., Whiteman, M., Finch, S., & Cohen, P. (1995). Aggression, intrapsychic distress, and drug use: Antecedent and intervening processes. *Journal of the American Academy of Child and Adolescent Psychiatry*, *34*, 1076−1084.

Brown, S., Tapert, S., Granholm, E., & Delis, D. (2000). Neurocognitive functioning of adolescents: Effects of protracted alcohol use. *Alcoholism, Clinical and Experimental Research*, *24*, 164−171.

Buss, A., & Perry, M. (1992). The aggression questionnaire. *Journal of Personality and Social Psychology*, *63*, 452−459.

Cahalan, D., Cisin, I. H., & Crossley, H. (1969). American drinking practices: A national study of drinking, behavior and attitudes. *Rutgers Center of Alcohol Studies Monograph*, *Vol. 1*. New Brunswick, NJ: Rutgers University Center of Alcohol Studies.

Carey, K. B., & Maisto, S. (1987). Effect of a change in drinking pattern on the cognitive function of female social drinkers. *Journal of Studies on Alcohol*, *48*, 236−242.

Casey, B., Trainor, R., Orendi, J., Schubert, A., Nystrom, L., Giedd, J., et al. (1997). A developmental functional MRI study of prefrontal activation during performance of go–no-go task. *Journal of Cognitive Neuroscience*, *9*, 835−845.

Chassin, L., Pillow, D., Curran, P., Molina, B., & Barrera, M. (1993). Relation of parental alcoholism to early adolescent substance use: A test of three mediating mechanisms. *Journal of Abnormal Psychology*, *102*, 3−19.

Cloninger, C., Sigvardsson, S., & Bohman, M. (1988). Childhood personality predicts alcohol abuse in young adults. *Alcoholism, Clinical and Experimental Research*, *12*, 494−505.

Cordilia, A. (1985). Alcohol and property crime: Exploring the causal nexus. *Journal of Studies on Alcohol*, *46*, 161−171.

Crown, S. (1952). An experimental study of psychological changes following prefrontal lobotomy. *Journal of General Psychology*, *47*, 3−41.

Deckel, A., Bauer, L., & Hesselbrock, V. (1995). Anterior brain dysfunction as a risk factor in alcoholic behaviors. *Addiction*, *90*, 1323−1334.

Deckel, A., & Hesselbrock, V. (1996). Behavioral and cognitive measurements predict scores on the MAST: A 3-year prospective study. *Alcoholism, Clinical and Experimental Research*, *20*, 1173−1178.

Demakis, G. (2003). A meta-analytic review of the sensitivity of the Wisconsin card sorting test to frontal and lateralized frontal brain damage. *Neuropsychology*, *17*, 255−264.

Diamond, A. (1991). Guidelines for the study of brain–behavior relationships during development. In H. Levin, H. Eisenberg, & A. Benton (Eds.), *Frontal lobe function and dysfunction* (pp. 339−378). New York: Oxford University Press.

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology*, *30*, 257−303.

Eckardt, M., Stapleton, J., Rawlings, R., Davis, E., & Grodin, D. (1995). Neuropsychological functioning in detoxified alcoholics between 18 and 35 years of age. *American Journal of Psychiatry*, *152*, 53−59.

Elsabagh, S., Hartley, D., Randall, D., Seth, P., & File, S. (2004). Mood changes after cognitive testing in late middle-age: Impacts of sex and habitual alcohol consumption. *Pharmacology, Biochemistry and Behavior*, *78*, 621−628.

Emmerson, R. Y., Dustman, R. E., Heil, J., & Shearer, D. E. (1988). Neuropsychological performance of young nondrinkers, social drinkers, and long- and short-term sober alcoholics. *Alcoholism, Clinical and Experimental Research*, *12*, 625−629.

Evert, D., & Oscar-Berman, M. (1995). Alcohol-related cognitive impairments: An overview of how alcoholism may affect the workings of the brain. *Alcohol Health and Research World*, *19*, 89−96.

Fals-Stewart, W., Schafer, J., Lucente, S., Fustine, T., & Brown, L. (1994). Neurobehavioral consequences of prolonged alcohol and substance abuse: A review of findings and treatment implications. *Clinical Psychology Review*, *14*, 755−778.

Finn, P. R. (2002). Motivation, working memory, and decision making: A cognitive-motivational theory of personality vulnerability to alcoholism. *Behavioral & Cognitive Neuroscience Reviews*, *1*, 183−205.

Finn, P. R., Mazas, C. A., Justus, A. N., & Steinmetz, J. (2002). Early-onset alcoholism with conduct disorder: Go/no go learning deficits, working memory capacity, and personality. *Alcoholism, Clinical and Experimental Research*, *26*, 186−206.

Fuster, J. (1989). *The prefrontal cortex: Anatomy, physiology, and neuropsychology of the frontal lobe* (2nd ed.). New York: Raven.

Fuster, J. (1995). Memory and planning: Two temporal perspectives of frontal lobe function. In H. Jasper, S. Riggio, & P. Goldman-Rakic (Eds.), *Epilepsy and the functional anatomy of the frontal lobe* (pp. 9−19). New York: Raven Press.

Galanis, D. J., Joseph, C., Masaki, K. H., Petrovitch, H., Ross, G. W., & White, L. (2000). A longitudinal study of drinking and cognitive performance in elderly Japanese American men: The Honolulu-Asia aging study. *American Journal of Public Health*, *90*, 1254−1259.

Giancola, P. R. (2004). Executive functioning and alcohol-related aggression. *Journal of Abnormal Psychology*, *113*, 541−555.

Giancola, P., & Moss, H. (1998). Executive cognitive functioning in alcohol use disorders. In M. Galanter (Ed.), *Recent developments in alcoholism: Vol. 14. The consequences of alcoholism* (pp. 227−251). New York: Plenum Press.

Giancola, P. R., & Mezzich, A. C. (2000). Neuropsychological deficits in female adolescents with a substance use disorder: Better accounted for by conduct disorder? *Journal of Studies on Alcohol*, *61*, 809−817.

Giancola, P. R., Mezzich, A. C., & Tarter, R. E. (1998). Disruptive, delinquent, and aggressive behavior in adolescent females with a psychoactive substance use disorder: Relation to executive cognitive functioning. *Journal of Studies on Alcohol*, *59*, 560−567.

Giancola, P. R., Moss, H. B., Martin, C. S., Kirisci, L., & Tarter, R. E. (1996). Executive cognitive functioning predicts reactive aggression in boys at high risk for substance abuse: A prospective study. *Alcoholism, Clinical and Experimental Research*, *20*, 740−744.

Giancola, P. R., & Parker, A. M. (2001). A six-year prospective analysis of pathways toward drug use in preadolescent boys with and without a family history of a substance use disorder. *Journal of Studies on Alcohol*, *62*, 166−178.

Giancola, P. R., Shoal, G. D., & Mezzich, A. C. (2001). Constructive thinking, executive cognitive functioning, antisocial behavior, and drug use in adolescent females with a substance use disorder. *Experimental and Clinical Psychopharmacology*, *9*, 215−227.

Giancola, P. R., & Tarter, R. E. (1999). Executive cognitive functioning and risk for substance abuse. *Psychological Science*, *10*, 203−205.

Giancola, P. R., Zeichner, A., Yarnell, J. E., & Dickson, K. E. (1996). Relation between executive cognitive functioning and the adverse consequences of alcohol use in social drinkers. *Alcoholism, Clinical and Experimental Research*, *20*, 1094−1098.

Gillen, R., & Hesselbrock, V. (1992). Cognitive functioning, ASP, and family history of alcoholism in young men at risk for alcoholism. *Alcoholism, Clinical and Experimental Research*, *16*, 206−214.

Goel, V., & Grafman, J. (1995). Are the frontal lobes implicated in "planning" functions? Interpreting data from the tower of Hanoi. *Neuropsychologia*, *33*, 623−642.

Hanlon, T., Nurco, D., Kinlock, T., & Duszynski, K. (1990). Trends in criminal activity and drug use over and addiction career. *American Journal of Drug and Alcohol Abuse*, *16*, 223−238.

Hannon, R., Butler, C. P., Day, C. L., Khan, S. A., Quitoriano, L. A., Butler, A. M, et al. (1985). Alcohol use and cognitive functioning in men and women college students. In M. Galanter (Ed.), *Recent developments in alcoholism*, *Vol. 3* (pp. 241–252). New York, NY: Plenum Press.

Hannon, R. H., Day, C. L., Butler, A. M., Larson, A. J., & Casey, M. B. (1983). Alcohol consumption and cognitive functioning in college students. *Journal of Studies on Alcohol*, *44*, 283−298.

Hartley, D. E., Elsabagh, S., & File, S. E. (2004). Binge drinking and sex: Effects of mood and cognitive function in healthy young volunteers. *Pharmacology, Biochemistry and Behavior*, *78*, 611−619.

Heaton, R. (1993). *Wisconsin card sorting test: Computer version-2.* Odessa, FL: Psychological Assessment Resources.

Hesselbrock, V., Stabenau, J., & Hesselbrock, M. (1985). Minimal brain dysfunction and neuropsychological test performance in offspring of alcoholics. In M. Galanter (Ed.), *Recent Developments in Alcoholism*, *Vol. 3* (pp. 65−82). New York: Plenum Press.

Kalmijn, S., van Boxtel, M. P., Verschuren, M. W., Jolles, J., & Launer, L. J. (2002). Cigarette smoking and alcohol consumption in relation to cognitive performance in middle age. *American Journal of Epidemiology*, *156*, 936−944.

Karnath, H., Wallesch, C., & Zimmermann, P. (1991). Mental planning and anticipatory processes with acute and chronic frontal lobe lesions: A comparison of maze performance in routine and non-routine situations. *Neuropsychologia*, *29*, 271−290.

Linnoila, M., DeJong, J., & Virkkunen, M. (1989). Family history of alcoholism in violent offenders and impulsive fire setters. *Archives of General Psychiatry*, *46*, 613−616.

Luria, A. (1980). *Higher cortical functions in man.* New York: Basic Books.

Lynam, D., Moffitt, T., & Stouthamer-Loeber, M. (1993). Explaining the relation between IQ and delinquency: Class, race, test motivation, school failure, or self-control? *Journal of Abnormal Psychology*, *102*, 187−196.

Lyvers, M. (2000). "Loss of control" in alcoholism and drug addiction: A neuroscientific interpretation. *Experimental and Clinical Psychopharmacology*, *8*, 225−249.

MacKinnon, D., Krull, J., & Lockwood, C. (2000). Equivalence of the mediation, confounding and suppression effect. *Prevention Science*, *1*, 173−181.

MacLeod, C. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, *109*, 163−203.

Malloy, P., Noel, N., Longabaugh, R., & Beattie, M. (1990). Determinants of neuropsychological impairment in antisocial substance abusers. *Addictive Behaviors*, *15*, 431−438.

Mâsse, L., & Tremblay, R. (1997). Behavior of boys in kindergarten and the onset of substance use during adolescence. *Archives of General Psychiatry*, *54*, 62−68.

Milner, B. (1995). Aspects of human frontal lobe function. In H. Jasper, S. Riggio, & P. Goldman-Rakic (Eds.), *Epilepsy and the functional anatomy of the frontal lobe* (pp. 67−84). New York: Raven Press.

Milner, B., & Petrides, M. (1984, November). Behavioural effects of frontal-lobe lesions in man. *Trends in Neurosciences*, 403−407.

Moffitt, T. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review*, *100*, 674−701.

Molina, B. S. G., & Pelham, W. E. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, *112*, 497−507.

Moss, H. (1989). Psychopathy, aggression, and family history in male veteran substance abuse patients: A factor analytic study. *Addictive Behaviors*, *14*, 565−570.

Moss, H., Kirisci, L., Gordon, H., & Tarter, R. (1994). A neuropsychologic profile of adolescent alcoholics. *Alcoholism, Clinical and Experimental Research*, *18*, 159−163.

Murphy, C. M., Winters, J., O'Farrell, T. J., Fals-Stewart, W., & Murphy, M. (2005). Alcohol consumption and intimate partner violence by alcoholic men: Comparing violent and nonviolent conflicts. *Psychology of Addictive Behaviors*, *19*, 35−42.

Newman, J., & Kosson, D. (1986). Passive avoidance learning in psychopathic and nonpsychopathic offenders. *Journal of Abnormal Psychology*, *95*, 252−256.

Nixon, S., Tivis, R., & Parsons, O. (1995). Behavioral dysfunction and cognitive efficiency in male and female alcoholics. *Alcoholism, Clinical and Experimental Research*, *19*, 577−581.

Nixon, S. J. (1999). Neurocognitive performance in alcoholics: Is polysubstance abuse important? *Psychological Science*, *10*, 181−185.

O'Donnell, J., Hawkins, J., & Abbott, R. (1995). Predicting serious delinquency and substance use among aggressive boys. *Journal of Consulting and Clinical Psychology*, *63*, 529−537.

O'Malley, S., Adamse, M., Heaton, R., & Gawin, F. (1992). Neuropsychological impairment in chronic cocaine abusers. *American Journal of Drug and Alcohol Abuse*, *18*, 131−144.

Parker, E. S., & Noble, E. P. (1977). Alcohol consumption and cognitive functioning in social drinkers. *Journal of Studies on Alcohol*, *38*, 1224−1232.

Parker, E. S., Parker, D. A., & Harford, T. C. (1991). Specifying the relationship between alcohol use and cognitive loss: The effects of frequency of consumption and psychological distress. *Journal of Studies on Alcohol*, *52*, 366−373.

Parsons, O. A. (1986). Cognitive functioning in sober social drinkers: A review and critique. *Journal of Studies on Alcohol*, *47*, 101−114.

Parsons, O. A., & Fabian, M. S. (1982). Comments on "Cognitive functioning in men social drinkers: A replication study". *Journal of Studies on Alcohol*, *43*, 178−182.

Parsons, O. A., & Nixon, S. J. (1998). Cognitive functioning in sober social drinkers: A review of the research since 1986. *Journal of Studies on Alcohol*, *59*, 180−190.

Perret, E. (1974). The left frontal lobe of man and the suppression of habitual responses in verbal categorical behaviour. *Neuropsychologia*, *12*, 323−330.

Peterson, J., Finn, P., & Pihl, R. (1992). Cognitive dysfunction and the inherited predisposition to alcoholism. *Journal of Studies on Alcohol*, *53*, 154−160.

Peterson, J., & Pihl, R. (1991). Information processing, neuropsychological function, and the inherited predisposition to alcoholism. *Neuropsychology Review*, *1*, 343−369.

Petrides, M. (1985). Deficits on conditional associative-learning tasks after frontal- and temporal-lobe lesions in man. *Neuropsychologia*, *23*, 601−614.

Petrides, M., Alivisatos, B., Evans, A., & Meyer, E. (1993). Dissociation of human mid-dorsolateral from posterior dorsolateral frontal cortex in memory processing. *Proceedings of the National Academy of Sciences of the United States of America*, *90*, 873−877.

Phillips, J. & Nixon, S. (1998). *Criminality in non-incarcerated female alcoholics*. Presented at the annual meeting of the Research Society on Alcoholism. Hilton Head Island, SC.

Pihl, R., & Peterson, J. (1991). Attention-deficit hyperactivity disorder, childhood conduct disorder, and alcoholism. *Alcohol Health and Research World*, *15*, 25−31.

Pihl, R., Peterson, J., & Finn, P. (1990a). An heuristic model for the inherited predisposition to alcoholism. *Psychology of Addictive Behaviors*, *4*, 12−25.

Pihl, R., Peterson, J., & Finn, P. (1990b). Inherited predisposition to alcoholism: Characteristics of sons of male alcoholics. *Journal of Abnormal Psychology*, *99*, 291−301.

Porteus, S. (1965). *Porteus maze test: Fifty year's application.* Palo Alto: Pacific Books.

Porteus, S., & Kepner, R. (1944). Mental changes after bilateral prefrontal lobotomy. *Genetic Psychology Monographs*, *29*, 3−115.

Pulkkinen, L., & Pitkanen, T. (1994). A prospective study of the precursors to problem drinking in young adulthood. *Journal of Studies on Alcohol*, *55*, 578−587.

Raine, A., Moffitt, T. E., Caspi, A., Loeber, R., Stouthamer-Loeber, M., & Lynam, D. (2005). Neurocognitive impairments in boys on the life-course persistent antisocial path. *Journal of Abnormal Psychology*, *114*, 38−49.

Reitan, R. (1992). *Trail making test: Manual for administration and scoring.* Tucson, AZ: Reitan Neuropsychological Laboratory.

Rezai, K., Andreasen, N., Alliger, R., Cohen, G., Swayze, V., & O'Leary, D. (1993). The neuropsychology of the prefrontal cortex. *Archives of Neurology*, *50*, 636−642.

Rosselli, M., & Ardila, A. (1996). Cognitive effects of cocaine and polydrug abuse. *Journal of Clinical and Experimental Neuropsychology*, *18*, 122−135.

Salloum, I., Daley, D., Cornelius, J., Kirisci, L., & Thase, M. (1996). Disproportionate lethality in psychiatric patients with concurrent alcohol and cocaine abuse. *American Journal of Psychiatry*, *153*, 953−955.

Sasaki, K., Gemba, H., Nambu, A., & Matsuzaki, R. (1993). Go–no-go activity in the frontal association cortex of human subjects. *Neuroscience Research*, *18*, 249−252.

Sayette, M. (1993). An appraisal-disruption model of alcohol's effects on stress responses in social drinkers. *Psychological Bulletin*, *114*, 459−476.

Seguin, J. R., Nagin, D., Assaad, J. M., & Tremblay, R. E. (2004). Cognitive-neuropsychological function in chronic physical aggression and hyperactivity. *Journal of Abnormal Psychology*, *113*, 603−613.

Selby, M., & Azrin, R. (1998). Neuropsychological functioning in drug abusers. *Drug and Alcohol Dependence*, *50*, 39−45.

Selzer, M., Vinokur, A., & van Rooijen, L. (1975). A self-administered short Michigan alcoholism screening test (SMAST). *Journal of Studies on Alcohol*, *36*, 117−126.

Sher, K., & Trull, T. (1994). Personality and disinhibitory psychopathology: Alcoholism and antisocial personality disorder. *Journal of Abnormal Psychology*, *103*, 92−102.

Sher, K., Walitzer, K., Wood, P., & Brent, E. (1991). Characteristics of children of alcoholics: Putative risk factors, substance use and abuse, and psychopathology. *Journal of Abnormal Psychology*, *100*, 427−448.

Sinha, R., Parsons, O. A., & Glenn, S. W. (1989). Drinking variables, affective measures and neuropsychological performance: Familial alcoholism and gender correlates. *Alcohol*, *6*, 77−85.

Skinner, H. A., & Allen, B. A. (1982). Alcohol dependence syndrome: Measurement and validation. *Journal of Abnormal Psychology*, *91*, 199−209.

Smith, M., & Oscar-Berman, M. (1992). Resource-limited information processing in alcoholism. *Journal of Studies on Alcohol*, *53*, 514−518.

Sobel, M. (1986). Some new results on indirect effects and their standard errors in covariance structure models. In N. Tuma (Ed.), *Sociological methodology* (pp. 159−186). Washington, DC: American Sociological Association.

Spreen, O., Risser, A. H., & Edgell, D. (1995). *Developmental neuropsychology.* New York: Oxford University Press.

Stampfer, M. J., Kang, J. H., Chen, J., Cherry, R., & Grodstein, F. (2005). Effects of moderate alcohol consumption on cognitive function in women. *New England Journal of Medicine*, *352*, 245−253.

Steele, C., & Josephs, R. (1990). Alcohol myopia: Its prized and dangerous effects. *American Psychologist*, *45*, 921−933.

Stout, J. C., Rock, S. L., Campbell, M. C., Busemeyer, J. R., & Finn, P. R. (2005). Psychological processes underlying risky decisions in drug abusers. *Psychology of Addictive Behaviors*, *19*, 148−157.

Stuss, D., & Alexander, M. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research*, *63*, 289−298.

Stuss, D., & Benson, D. (1984). Neuropsychological studies of the frontal lobes. *Psychological Bulletin*, *95*, 3−28.

Stuss, D., Floden, D., Alexander, M., & Katz, D. (2001). Stroop performance in focal lesion patients: Dissociation of processes and frontal lobe lesion location. *Neuropsychologia*, *39*, 771−786.

Sullivan, E., Rosenbloom, M., & Pfefferbaum, A. (2000). Pattern of motor and cognitive deficits in detoxified alcoholic men. *Alcoholism, Clinical and Experimental Research*, *24*, 611−621.

Tapert, S., & Brown, S. (1999). Neuropsychological correlates of adolescent substance abuse: Four-year outcomes. *Journal of the International Neuropsychological Society*, *5*, 481−493.

Tarter, R., Mezzich, A., Hsieh, Y., & Parks, S. (1995). Cognitive capacity in female adolescent substance abusers. *Drug and Alcohol Dependence*, *39*, 15−21.

Tarter, R., & Parsons, O. (1971). Conceptual shifting in chronic alcoholics. *Journal of Abnormal Psychology*, *77*, 71−75.

Tarter, R., & Vanyukov, M. (1994). Alcoholism: A developmental disorder. *Journal of Consulting and Clinical Psychology*, *62*, 1096−1107.

Tarter, R. E. (1989). *Drug Use Questionnaire*. Unpublished questionnaire from the Center for Education and Drug Abuse Research. University of Pittsburgh.

Tarter, R. E., Vanyukov, M. M., Giancola, P. R., Dawes, M. A., Blackson, T. C., Mezzich, A. C., et al. (1999). Etiology of early age onset substance use disorder: A maturational perspective. *Development and Psychopathology*, *11*, 657−683.

Tivis, R., Beatty, W., Nixon, S., & Parsons, O. (1995). Patterns of cognitive impairment among alcoholics: Are there subtypes? *Alcoholism, Clinical and Experimental Research*, *19*, 496−500.

Tremblay, P. R., & Ewart, L. A. (2005). The Buss and Perry aggression questionnaire and its relations to values, the big five, provoking hypothetical situations, alcohol consumption patterns, and alcohol expectancies. *Personality and Individual Differences*, *38*, 337−346.

Waugh, M., Jackson, M., Fox, G. A., Hawke, S. H., & Tuck, R. R. (1989). Effect of social drinking on neuropsychological performance. *British Journal of Addiction*, *84*, 659−667.

Williams, C. M., & Skinner, A. E. (1990). The cognitive effects of alcohol abuse: A controlled study. *British Journal of Addiction*, *85*, 911−917.

Williams, T., Boyd, J., Cascardi, M., & Poythress, N. (1996). Factor structure and convergent validity of the aggression questionnaire in an offender population. *Psychological Assessment*, *8*, 398−403.

Windle, M. (1990). A longitudinal study of antisocial behaviors in early adolescence as predictors of late adolescent substance use: Gender and ethnic group differences. *Journal of Abnormal Psychology*, *99*, 86−91.

Windle, M. (1993). A retrospective measure of childhood behavior problems and its use in predicting adolescent problem behaviors. *Journal of Studies on Alcohol*, *54*, 422−431.

Wood, M., Sher, K., & Erickson, D. (1995, June). *Prospective prediction of substance use disorders from personality measures*. Paper presented at the annual meeting of the Research Society on Alcoholism, Steamboat Springs, CO.

Zuckerman, M. (1987). Is sensation seeking a predisposing trait for alcoholism? In E. Gottheil, K. Druley, S. Pashko, & S. Weinstein (Eds.), *Stress and addiction* (pp. 283−301). New York: Brunner/Mazel.