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Effects of alcohol and cigarette use on cognition in middle-aged adults

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Abstract

In this retrospective cohort study we examined the independent and interactive effects of drinking and smoking on cognition in a sample of 3361 males, ages 31 to 49, with varying lifetime histories of alcohol and cigarette use. Dependent variables were neuropsychological measures of global and specific cognitive abilities. Comparison of the ability scores of seven groups, defined by their drinking and smoking histories, explained only 5.4% of the multivariate variance in cognitive ability and less than 2% in any individual cognitive measure. Regression analyses for current drinkers and smokers showed only a single significant, but negligible, effect of pack-years of smoking on a measure of global cognitive ability. Differences in cognitive function in groups defined by intensity of alcohol and cigarette use revealed no significant effect for drinking and a significant, but very small, effect for smoking. (*JINS*, 2002, *8*, 683–690.)

Keywords: Aging, Cognition, Neuropsychological tests, Risk factors, Alcohol drinking, Smoking

INTRODUCTION

While neuropsychological studies have consistently shown that chronic alcoholism is associated with loss of function in higher-order cognitive abilities such as problem-solving, abstract reasoning, visual–spatial analysis, and learning and memory (e.g., Grant, 1987; Rourke & Loberg, 1996), studies of the impact of alcohol use on cognition in nonclinical samples of drinkers have not been as clearcut. Several recent studies of community samples (e.g., Elias et al., 1999; Hendrie et al., 1996) have found that beneficial curvilinear or threshold effects best described the relation between alcohol consumption and cognitive performance. In a recent study (Elias et al., 1999), for example, occasional or light drinkers performed at the same or even slightly lower level than abstainers, but moderate drinkers performed at a higher level than abstainers and light drinkers. These findings are not uniformly reported, however. Positive effects for women, but not for men, have been reported (Dufouil et al., 1997), and a failure to find any differences in cognitive performance between current and abstinent individuals has also been reported (Dent et al., 1997). Studies in middle-aged (ages 30–60) samples are also inconclusive, with smaller clinical studies (Emmerson et al., 1988; Page & Cleveland, 1987; Waugh et al., 1989; Williams & Skinner, 1990) and large community-based studies (Cerhan et al., 1998; Parker et al., 1991) showing both beneficial and detrimental effects.

Surprisingly, there is little research that has examined the effect of smoking on cognition, and no study that has examined the potential interactive effect of both smoking and drinking on cognition, despite the high frequency of their concordant use (DiFranza & Guerrera, 1990), their common genetic factors (Swan et al., 1996, 1997), and their contribution as risk factors to overall health status. In the elderly, several studies suggest that smoking history has no impact on cognition (Carmelli et al., 1997; Dufouil et al., 1997), but cognitive decline has been reported in smokers (Kilander et al., 1997), in smokers and ex-smokers (Gala-

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nis et al., 1997), and in smokers but not ex-smokers (Launer et al., 1996). A single study (Cerhan et al., 1998) has reported lowered cognitive ability in middle-aged smokers.

Inconsistency in the results of studies examining the impact of smoking and drinking on cognitive ability would not be unexpected, given the variability across studies in several methodological factors, such as participant sampling, measures of cognition, and range and type of consumption. Several of these variables appear to be especially critical. Because alcohol and cigarette consumption are related to education (Slater et al., 1999), and education is an especially strong predictor of cognitive ability (e.g., Vanderploeg & Schinka, 1995), statistical control of years of education is critical. Other variables that potentially confound comparisons between abstainers and users because of their association with use of alcohol and/or cigarettes and their impact on cognitive function include history of vascular disease, diabetes, and hypertension (Haan et al., 1999). A comprehensive analysis of the impact of drinking and smoking on cognition should also include analyses not only by category of use (abstainer, user, ex-user), but also of lifetime consumption. In one report (Page & Cleveland, 1987), for example, significant results were obtained for comparisons of groups based on category of smoking use, but not for analyses based on pack-year history. Finally, adequate measurement of cognitive function should include more sensitive measures of global function, as well as measures of important domains of cognition.

Interestingly, few studies have addressed the complex issue of defining "social," normal range, or nonalcoholic drinking. Most of the community based studies have not screened samples to exclude alcoholics, but have instead limited participation to individuals consuming fewer than 8 to 10 drinks per day. Obviously, this strategy does not exclude alcoholics, but it does probably limit the frequency of alcoholics in the sample to a low percentage, especially because it is unlikely that alcoholics voluntarily enroll in community-based studies. Because the formal diagnosis of alcoholism is based on criteria other than frequency and amount of alcohol consumption (e.g., withdrawal, reduced level of social, recreational, or occupational activities), screening participants on the basis of alcohol consumption would presumably be successful only if a very low level of consumption (e.g., 4 drinks or 48 g of pure alcohol per day) were used to exclude participants. However, such a strategy would also have the unfortunate effect of reducing variance and thus limiting the possibility of uncovering relationships with cognitive variables. Parsons and Nixon (1998) concluded that, in those studies showing detrimental effects of drinking in sober drinkers, cognitive inefficiencies could be measured with sustained periods of consumption of five or six drinks per day and became more likely at the level of seven to nine drinks per day. Thus, estimating the effect of drinking on cognition would appear to require samples with a fairly wide range of daily consumption.

Using data from the Vietnam Experience Study (Centers for Disease Control, 1988a; 1988b), we retrospectively examined the independent and interactive impact of smoking and drinking on cognitive ability in a large sample of middle-aged men. The size and comprehensive nature of the study allowed us to examine effects across several measures of cognitive ability, control for confounding effects of other disorders, adjust cognitive performance for level of ability in late adolescence, and perform statistical analyses with sufficient power to detect small effect sizes.

METHODS

Research Participants

Participants were 4462 army veterans from a mid-1980s study investigating the effects of the Vietnam experience on veterans [the Vietnam Experience Study (VES); Centers for Disease Control, 1988a, 1988b] who completed comprehensive medical, psychological, and neuropsychological examinations. From this group we selected only those individuals who had no history of smoking or whose smoking history included only cigarette use (and not other smoking products) starting at age 14 or older. Following the work of Parsons and Nixon (1998), we excluded participants with a history of consuming 9 or more drinks per day with the intention of eliminating severe alcoholics from the sample but allowing for a sufficient range of drinking to allow examination of drinking-cognition relationships. Participants were not excluded for the presence of psychiatric disorder. Individuals with a history of cardiac failure, hypertension, diabetes, or head injury with loss of consciousness were excluded to control for possible confounding influences on cognitive function. Fifteen individuals were excluded for missing or inconsistent data. The final sample for analysis consisted of 3361 individuals, ages 31 to 49.

Measures

All participants completed a comprehensive neuropsychological battery, administered by trained examiners, that included measures of the following cognitive abilities: verbal list learning and recall, constructional ability, memory for complex figure, verbal fluency, concept formation, sustained attention, fine motor performance, and global cognitive ability. The measure of global cognitive ability was the General Technical (GT) score of the Army Classification Battery (Montague et al., 1957), which is a standardized aptitude test that was administered prior to induction into the military and again as part of the VES. Measures of each of the cognitive abilities are presented in Table 1.

The VES data set contained several examiner-queried, self-report variables measuring the amount and frequency of alcohol use and smoking. We derived two additional variables to provide measures of lifetime total consumption to facilitate analyses. The first of these was the pack-year, which was computed as the number of cigarettes smoked per day, divided by 20 (the number of cigarettes in a pack), multiplied by the number of years of smoking. A similar

Table 1. List of measures of cognitive ability

Cognitive ability	Measure
Verbal list learning	California Verbal Learning Test[a] sum of trials 1–5 score
Verbal memory	California Verbal Learning Test[a] long delay free recall score
Constructional ability	Block Design score of Wechsler Adult Intelligence Scale–Revised[b]
Memory for complex figure	Rey-Osterreith Complex Figure delayed recall score[c]
Verbal fluency	Semantic Fluency score (animal naming)[d]
Concept formation	Wisconsin Card Sorting Test categories sorted score[e]
Sustained attention	Paced Auditory Serial–Addition Test: Trial 1 raw score[f]
Fine motor performance	Grooved Pegboard dominant hand score[g]
Global cognitive ability	General Technical score[h]

[a]Delis et al., 1983; [b]Wechsler, 1981; [c]Rey, 1941; [d]Goodglass & Kaplan, 1983; [e]Berg, 1941; [f]Gronwall, 1997; [g]Matthews & Klove, 1964; [h]Montague et al., 1957.

measure was employed to measure drinking. A drink-year was defined as follows: number of drinks per day multiplied by the number of years drinking. No distinction was made between various forms of alcoholic beverage (1 can/bottle/glass beer = 1 glass wine = 1 hard liquor drink). Those individuals who reported that they had never had a period of 12 months in which they had consumed one drink per month were categorized as nondrinkers. Those individuals who denied regular use of cigarettes (at least 1 per day) at any time and reported lifetime consumption of fewer than 100 cigarettes were categorized as nonsmokers.

Statistical Analyses

Three sets of analyses were conducted. In the first set the sample was subdivided into seven groups, based on drinking and smoking histories (see Table 2). Because use of alcohol and cigarettes is related to age, education, and level of cognitive ability, participants were selected to equate groups as closely as possible on the variables of age, years of formal education, and military enlistment General Technical Test score. To equate groups, the variable distributions for the entire samples and all groups were first examined. The changes in the group distribution parameters that would be required to equate the distributions were then estimated. Cases were then randomly selected from segments of the distributions to produce the distributions with the desired parameters. Differences in cognitive performance among the groups were examined by means of a one-way multivariate analysis of variance (MANOVA), with 1 − Wilks's Lambda used to estimate the variance in the entire set of ability measures explained by group membership. Followup univariate analyses of variance (ANOVA) were then conducted, in order to derive estimates of the amount of variance (η^2) in each measure of cognitive ability explained by smoking and drinking.

In the second set of analyses hierarchical multiple linear regression methods were used with the sample of participants who were current drinkers and smokers ($n = 1118$). For regression analyses, variables were entered simultaneously in sequential blocks of sets of variables in this order: control variables (age, education, induction GT score), drink-years, pack-years, and the interaction of drink-years and pack-years. Separate regression analyses were conducted for each cognitive ability measure. For regression analyses, the change in R^2 was used to estimate variance contributions at sequential steps in the analysis (Table 3).

In the final set of analyses, multivariate analyses of covariance (MANCOVA) procedures were used to examine the impact of intensity of alcohol and cigarette use on cognitive function. Separate MANCOVAs were conducted for alcohol and cigarette use. For drinking, current drinkers with at least a 10-year period of .5 to 2 drinks per day were identified as *medium intensity drinkers*. Current drinkers with at least a 10-year period of 4 to 8 drinks per day were identified as *high intensity drinkers*. Three groups of individuals were used in this analysis: *lifetime abstainers*, *medium-intensity drinkers*, and *high-intensity drinkers*. A one-way MANCOVA, with cigarettes per day as a covariate control variable, was used to test the hypothesis of differences in performance on the set of cognitive measures, with 1− Wilks's Lambda used as an estimate of the contribution of group membership to variance in the set of ability scores. Follow-up univariate analyses of covariance (ANCOVA) were then conducted in order to derive estimates of the amount of variance (η^2) in each measure of cognitive ability. A parallel analysis was performed for smoking intensity, using lifetime abstainers, medium-intensity (10–19 cigarettes per day for at least 5 years) smokers, and high-intensity ($>$39 cigarettes per day for at least 5 years) smokers. For these analyses, drinking amount (drinks per day) was used as a covariate. Characteristics of the groups used in these analyses are provided in Tables 4 and 5.

Power analyses were conducted for the MANOVA, MANCOVA, and regression analyses. Power to detect a small effect with alpha set at .05 was estimated as being greater than .80 for these analyses. Alpha was set at .01 for regression analyses and for followup ANOVA and ANCOVA analyses to protect against error for the family-wide number of analyses.

Table 2. Demographic and neuropsychological characteristics for smoking/drinking subgroups for lifetime use

	Groups													
	Never smoked/ never drank (n = 204)		Never smoked/ current drinker (n = 275)		Ex-smoker/ ex-drinker (n = 80)		Ex-smoker/ current drinker (n = 127)		Current smoker/ never drank (n = 174)		Current smoker/ ex-drinker (n = 228)		Current smoker/ current drinker (n = 460)	
Variable	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Demographic and substance use variables														
Age	38.36	(2.25)	38.37	(2.39)	38.60	(2.92)	37.96	(2.27)	38.41	(2.49)	38.03	(2.35)	37.97	(2.44)
Years of education[a]	12.76	(1.62)	12.66	(1.39)	12.66	(1.83)	13.01	(1.82)	12.88	(2.26)	12.34	(2.08)	12.74	(2.10)
Years of smoking	—	—	—	—	11.72	(5.81)	9.81	(5.22)	17.24	(5.35)	18.44	(4.44)	18.32	(4.82)
Pack-years	—	—	—	—	16.02	(12.64)	13.27	(12.56)	20.29	(11.97)	24.05	(12.07)	24.68	(14.57)
Years since smoked	—	—	—	—	8.75	(4.80)	9.51	(4.61)	—	—	—	—	—	—
Years of drinking	—	—	19.78	(2.85)	13.14	(4.94)	20.72	(2.68)	—	—	12.51	(5.42)	20.12	(3.08)
Drink-years	—	—	27.58	(29.29)	43.52	(27.89)	66.38	(32.94)	—	—	35.18	(37.80)	73.43	(38.37)
Years since drank	—	—	—		8.09	(4.63)	—	—	—		7.43	(5.18)	—	—
Global cognitive ability (at enlistment)	103.23	(16.75)	101.99	(16.85)	103.46	(19.07)	104.55	(14.88)	102.30	(14.44)	102.26	(18.50)	102.97	(19.75)
Neuropsychological measures														
Fine motor	73.41	(12.35)	72.80	(12.79)	72.23	(11.55)	71.13	(10.78)	75.00	(10.99)	74.58	(13.00)	74.63	(11.93)
Sustained attention	37.94	(10.09)	36.92	(11.26)	38.13	(12.63)	39.18	(10.47)	37.10	(11.37)	38.49	(10.53)	39.46	(9.56)
Verbal fluency	20.18	(5.06)	19.18	(4.82)	20.63	(4.77)	20.56	(5.28)	19.70	(4.98)	20.33	(5.44)	20.22	(5.05)
Constructional ability[b]	10.35	(2.57)	10.25	(2.75)	10.41	(2.58)	10.88	(2.50)	10.15	(2.63)	10.21	(2.40)	9.94	(2.46)
Verbal list learning	45.16	(8.61)	44.28	(8.52)	44.20	(8.71)	46.76	(8.22)	45.23	(8.20)	45.93	(8.48)	46.41	(8.94)
Verbal recall[c]	9.65	(2.46)	9.33	(2.76)	9.43	(2.65)	10.30	(2.66)	9.57	(2.74)	9.73	(2.73)	9.95	(2.92)
Memory–complex design	20.47	(6.38)	19.52	(6.28)	20.55	(6.55)	20.05	(5.81)	19.96	(5.75)	19.75	(6.39)	19.16	(6.73)
Concept formation	5.17	(1.59)	5.15	(1.49)	5.22	(1.51)	5.20	(1.47)	5.22	(1.52)	5.36	(1.26)	5.13	(1.49)
Global cognitive ability (current)	108.57	(18.04)	104.98	(20.51)	110.31	(22.29)	110.37	(16.85)	105.83	(20.61)	106.64	(20.79)	106.78	(21.85)

Note. Total sample size = 1548; never smoked/ex-drinker and ex-smoker/never drank groups are not included because of insufficient sample sizes. [a]Current smoker/ex-drinker less than ex-smoker/current drinker $p < .05$. [b]Current smoker/current drinker less that ex-smoker/current drinker $p < .05$. [c]Never smoked/current drinker less than ex-smoker/current drinker $p < .05$.

Table 3. Results of regression analyses for factors influencing cognitive test performances in all current smokers/current drinkers

Test score	Variables entered	R^2	R^2 change	F change	p value
Fine motor	Age, education, GCA	.051	.051	19.587	.000
	Drink years	.051	.000	.025	.874
	Pack years	.053	.002	2.282	.131
	Drink years ∗ pack years	.054	.001	.619	.432
Sustained attention	Age, education, GCA	.215	.215	100.500	.000
	Drink years	.217	.001	1.580	.209
	Pack years	.217	.001	1.026	.311
	Drink years ∗ pack years	.219	.001	2.028	.155
Verbal Fluency	Age, education, GCA	.119	.119	49.793	.000
	Drink years	.120	.001	.368	.544
	Pack years	.346	.000	.131	.718
	Drink years ∗ pack years	.120	.000	.029	.865
Constructional Ability	Age, education, GCA	.258	.258	127.632	.000
	Drink years	.259	.001	1.003	.317
	Pack years	.260	.001	1.582	.209
	Drink years ∗ pack years	.260	.000	.334	.558
Verbal list learning	Age, education, GCA	.191	.191	86.907	.000
	Drink years	.193	.002	2.053	.152
	Pack years	.193	.000	.003	.960
	Drink years ∗ pack years	.195	.002	2.510	.113
Verbal recall	Age, education, GCA	.154	.154	66.919	.000
	Drink years	.155	.001	.639	.424
	Pack years	.155	.000	.251	.616
	Drink years ∗ pack years	.157	.002	2.653	.104
Memory–complex design	Age, education, GCA	.137	.137	58.129	.000
	Drink years	.137	.000	.001	.971
	Pack years	.137	.000	.066	.798
	Drink years ∗ pack years	.141	.004	5.045	.025
Concept formation	Age, education, GCA	.066	.066	26.041	.000
	Drink years	.066	.000	.001	.976
	Pack years	.070	.004	4.189	.041
	Drink years ∗ pack years	.070	.000	.321	.571
Global cognitive ability (current)	Age, education, GCA	.716	.716	927.323	.000
	Drink years	.717	.001	1.589	.208
	Pack years	.719	.002	8.121	.004
	Drink years ∗ pack years	.719	.000	.000	.998

Note. $N = 1118$. GCA = Global cognitive ability at time of military enlistment. Demographic, smoking, and drinking characteristics as follows: age $M = 37.95$ ($SD = 2.45$, range = 31–46), education $M = 13.00$ ($SD = 2.12$, range = 7–18), enlistment General Technical score $M = 104.19$ ($SD = 19.40$, range = 44–152), pack years $M = 21.92$ ($SD = 13.52$, range = 0–100), drink years $M = 42.82$ ($SD = 41.46$, range = .6–350).

RESULTS

Table 2 presents descriptive statistics for the performance of the seven drinking/smoking groups on each of the cognitive ability measures. The results of the MANOVA comparing the groups was significant [Wilks's $\lambda = .943$, $F(54,7796) = 1.664$, $p = .002$, $1 - \lambda = .057$], indicating that differences in drinking and smoking across groups explained 5.7% of the multivariate variance in cognitive ability scores. Results of followup ANOVAs for each of the individual cognitive ability measures produced no significant (all $ps > .01$) findings, however. Additionally, group differences in lifetime patterns of drinking and smoking did not explain as much as 2% of the variance in any individual cognitive ability measure.

The results of regression analyses for the effects of lifetime consumption of alcohol and cigarette use in current users are presented in Table 3. As expected, in each analysis the control variables of age, education, and global cognitive ability at time of enlistment accounted for significant amounts of variance in cognitive ability scores. For alcohol and cigarette use variables, however, only a

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Table 4. Demographic and neuropsychological characteristics for drinking intensity groups

	Drinking intensity					
	Never drank ($n = 608$)		.5–2 Drinks per day ($n = 638$)		4–8 Drinks per day ($n = 170$)	
Variable	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Demographic and substance use variables						
Age[a]	38.52	(2.52)	38.18	(2.54)	37.70	(2.33)
Years of education[b]	13.23	(2.27)	13.08	(2.16)	12.58	(2.19)
Cigarette packs per day	0.58	(0.72)	0.95	(0.75)	1.31	(0.75)
Years of drinking	0.0	(0.0)	20.03	(2.96)	19.85	(3.06)
Global cognitive ability (at enlistment)	101.32	(19.53)	101.73	(19.43)	100.81	(19.30)
Neuropsychological measures						
Fine motor[c]	74.04	(11.84)	72.69	(10.99)	75.30	(15.05)
Sustained attention	37.32	(11.11)	38.36	(10.57)	38.11	(10.61)
Verbal fluency	19.95	(4.99)	20.22	(5.25)	20.08	(5.30)
Constructional ability	10.28	(2.60)	10.29	(2.65)	9.98	(2.73)
Verbal list learning	45.18	(8.98)	45.46	(8.60)	45.13	(9.27)
Verbal recall	9.61	(2.70)	9.75	(2.66)	9.65	(2.92)
Memory–complex design	20.21	(6.15)	19.78	(6.06)	19.36	(6.76)
Concept formation	5.25	(1.49)	5.23	(1.40)	4.99	(1.59)
Global cognitive ability (current)	106.77	(21.78)	106.54	(22.04)	103.76	(22.96)

Note. [a]4–8 drinks per day group significantly younger than the other two groups, $p < .05$. [b]4–8 drinks per day group significantly fewer years of education than the other two groups, $p < .05$. [c].5–2 drinks per day group significantly better than 4–8 drinks per day group, $p < .05$.

single significant finding was produced by these analyses. Scores on the measure of global cognitive function were significantly reduced by the number of pack-years of smoking. Pack-years of smoking explained only .2% of the variance in the global cognitive function scores, however.

Descriptive statistics for the drinking and smoking intensity groups are presented in Tables 4 and 5. The results of

Table 5. Demographic and neuropsychological characteristics for smoking intensity groups

	Smoking intensity					
	Never smoked ($n = 673$)		.5 to 1 pack per day ($n = 768$)		2 or more packs per day ($n = 255$)	
Variable	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Demographic and substance use variables						
Age[a]	38.61	(2.47)	38.03	(2.48)	38.00	(2.37)
Years of education[b]	13.52	(2.22)	12.88	(2.13)	12.32	(2.21)
Drinks per day	0.63	(1.08)	1.32	(1.59)	2.00	(2.11)
Years of smoking	0.0	(0.0)	17.69	(4.78)	18.69	(4.55)
Global cognitive ability (at enlistment)	102.50	(19.97)	102.25	(19.00)	103.11	(18.80)
Neuropsychological measures						
Fine motor	73.77	(13.01)	73.98	(11.46)	74.93	(9.54)
Sustained attention	37.13	(11.11)	38.04	(10.72)	38.68	(10.46)
Verbal fluency	19.83	(5.11)	20.34	(5.12)	20.45	(5.12)
Constructional ability	10.30	(2.72)	10.09	(2.52)	10.26	(2.45)
Verbal list learning	44.63	(8.92)	45.83	(8.89)	45.40	(8.79)
Verbal recall	9.47	(2.77)	9.73	(2.71)	9.82	(2.73)
Memory–complex designs	19.99	(6.46)	19.45	(6.24)	19.15	(6.57)
Concept formation	5.23	(1.45)	5.21	(1.46)	5.33	(1.40)
Global cognitive ability (current)	107.13	(22.19)	106.82	(21.91)	108.46	(20.82)

Note. [a]Never smoked group significantly older than the other two groups, $p < .05$. [b]All three groups differ significantly from each other, $p < .05$.

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the MANCOVA for the effect of drinking intensity on the set of cognitive measures was not significant [Wilks's λ = .983, $F(18, 2838) = 1.332$, $p = .164$, $1 - \lambda = .017$], and indicated that amount of daily drinking explained only 1.7% of variance in the set of cognitive ability measures. Results for the effect of smoking intensity, however, were significant [Wilks's $\lambda = .980$, $F(18, 3388) = 1.922$, $p = .011$, $1 - \lambda = .020$], indicating that amount of daily smoking explained about 2% of variance in the set of cognitive ability measures. Followup ANCOVAs, however, showed that there was no specific significant drinking intensity effect on any of the individual cognitive measures. Results of followup ANCOVAs for individual cognitive measures for both the drinking and smoking intensity analyses showed effect sizes that were unsubstantial, explaining less than .5% of the variance.

DISCUSSION

The focus of this retrospective study was the effect of drinking and smoking, and their interactive effects, on cognitive ability. We had the benefit of a large sample, with drinking habits spanning the range typically considered to be within broad normal limits (i.e., fewer than 9 drinks per day). Multiple measures of cognitive ability allowed us the opportunity to examine differential effects of drinking and smoking on specific higher-order cognitive functions. Our analyses examined potential effects from several perspectives, examining the impact of broad categories of lifetime use, of intensity of daily use, and of the relationship of amount of use with cognitive ability. These analyses were well-controlled by the exclusion of participants with medical conditions that might affect performance, and by controlling for age, education, and global cognitive ability level at the time of military enlistment. Even with the statistical power afforded by our large sample, we found few significant results. More importantly, even when significant results were obtained, the effect sizes were very small and thus argued against consideration of the smoking and drinking variables as being important factors in affecting cognitive status in the middle-aged.

Our results are in contrast to several previous studies (see Parsons & Nixon, 1998) that did report an adverse effect of drinking on cognitive performance at the level of 5 drinks per day. This discrepancy cannot be attributed to the amount of alcohol consumed, as the range of alcohol consumed by our participants included the range considered to be harmful in previous research. The discrepancy also cannot be attributed to sensitivity of cognitive measures, as the measures in our analyses represent several commonly used and well-studied neuropsychological tests. Additionally, the substantial size of our sample provided power exceeding .80 for all analyses—power greater than that of the large majority of reviewed studies. Our results are more consistent with several studies (Dent et al., 1997; Elias et al., 1999; Dufouil et al., 1997), conducted primarily with elderly samples, that have found either no effect or small positive effects of alcohol consumption on cognitive performance.

Our results also revealed no substantial harmful effects of smoking, either alone or in combination with alcohol use, on cognitive performance. A previous study (Cerhan et al., 1998) did report a small effect of smoking on a digit symbol substitution task, a measure not included in the VES. Our results are consistent with that study's failure to find a substantial smoking effect on memory and verbal fluency tasks.

In summary, our results fail to demonstrate any substantial influence of alcohol use or smoking within broad normal ranges of use on cognitive function in middle-aged men. Several caveats are dictated by the design of the original VES research, however. In any form of cohort study, it is possible that heavier drinkers and/or smokers with cognitive sequelae may have higher refusal rates of participation, thus biasing the study in terms of participation of "healthy" heavy drinkers and smokers. Our conclusions are also tempered by the fact that the study was largely retrospective in nature and relied on self-report responses for measures of drinking and smoking frequency and amount. However, it is likely that self-report bias in the interviews would be in the direction of minimizing the degree of smoking or drinking. The effect of such a bias would therefore be to provide a more conservative test of the hypothesis that drinking and smoking within the reported ranges does not have an impact on cognition. Although we had no women participants in our analyses, previous studies (e.g., Elias et al., 1999) have demonstrated that results for women for drinking largely parallel those for men, albeit at lower levels (usually lower by 1–2 drinks per day) of consumption when there have been positive findings. Our results may tentatively apply to women, at estimated levels of consumption of 1 to 6 drinks per day.

Finally it is critical to note that our analyses examined the *direct* effects of alcohol and cigarette use on cognitive function; that is, after controlling for the *indirect* effects that might be caused by disorders for which drinking and smoking are potential risk factors, such as hypertension, diabetes, and vascular disease. As a concluding statement we might then say that alcohol use and smoking increase the risk and severity of disorders that may ultimately have a significant impact on health and cognition. However, for those who are spared these associated disorders, moderate use of alcohol and cigarettes appear to be without adverse cognitive effects in middle aged men.

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