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Recovery of Short-Term Memory and Psychomotor Speed but Not Postural Stability With Long-Term Sobriety in Alcoholic Women

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The authors assessed effects of extended abstinence on cognitive and motor function deficits previously observed in a group of alcoholic women ($n = 43$) initially tested after 15 weeks of sobriety. Alcoholic women were retested 1 and 4 years later, and control women were retested 3 years later. At Year 1, 14 of 23 returners had maintained sobriety, but they did not perform significantly better than relapsers; the group as a whole continued to show deficits relative to age norms. By Year 4, 13 of 14 returners had maintained sobriety for more than 30 months; as a group, these women had returned to normal levels on tests of memory and psychomotor speed but remained impaired in standing balance.

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The deleterious effects of chronic excessive alcohol use on cognitive and motor functions are well known. Less well understood are the prospects for and time course of recovery of function with sobriety. In general, cognitive recovery in alcoholism has been investigated with cross-sectional designs in which groups of alcoholics with lengths of sobriety varying from days to several years are compared with each other or with a nonalcoholic control group (e.g., Brandt, Butters, Ryan, & Bayog, 1983; Hochla, Fabian, & Parsons, 1982; Markowitsch, Kessler, & Denzler, 1986; Munro, Saxton, & Butters, 2000; Reed, Grant, & Rourke, 1992). This approach allows inferences about recovery but does not provide direct information about the time course of recovery. Longitudinal studies provide more direct information about cognitive recovery and can further control for practice and aging effects when a matched nonalcoholic group is retested at comparable intervals (e.g., Fabian & Parsons, 1983; Glenn, Parsons, & Sinha, 1994; Rourke & Grant, 1999; Yohman, Parsons, & Leber, 1985). Even without a nonalcoholic control group, naturalistic longitudinal studies of recovering alcoholics can yield valuable comparisons between abstainers and relapsers (Drake et al., 1995; Muuronen, Bergman, Hindmarsh, & Telakivi, 1989; Schafer et al., 1991; Sullivan, Rosenbloom, Lim, & Pfefferbaum, 2000).

Most cross-sectional and longitudinal studies report evidence linking sobriety to at least partial recovery of selected functions. However, although alcoholics who have been sober for about 1 year may show fewer deficits than alcoholics who have been recently detoxified, these 1-year sober alcoholics remain impaired on selective tests relative to control participants (Hochla et al., 1982; Munro et al., 2000; Parsons, Kim, & Glenn, 1990). By contrast, alcoholics with several years of sobriety are more likely to be comparable with nonalcoholic control participants (Brandt et al., 1983; Grant, Adams, & Reed, 1984; Reed et al., 1992). Despite the range of methods used and time lines covered, the message emerging from these studies is clear: Abstinence contributes to recovery, and longer abstinence contributes to greater recovery, but recovery can be selective.

The main focus of studies on functional deficits associated with alcoholism has long been exclusively on men. Although this is changing (cf. Nixon & Glenn, 1995), only one published longitudinal study has focused exclusively on women (Fabian & Parsons, 1983). There is considerable justification for studying the untoward effects of alcohol separately in men and women. As a group, women metabolize alcohol differently than men (Li et al., 2000; Lieber, 2000) and are more likely to experience problems associated with the same level of alcohol consumption (Ely, Hardy, Longford, & Wadsworth, 1999). Also, although women in general start drinking later in life, drink less per occasion, and are more likely to be abstinent than men, there is growing evidence that these gender differences in drinking patterns are declining as women increase their alcohol consumption (Mercer & Khavari, 1990).

There is limited evidence for marked differences in effect of alcoholism on cognitive function in men and women. Yet, once normal sex differences in cognitive performance are accounted for (Crawford & Ryder, 1986; Glenn & Parsons, 1992; Nixon & Glenn, 1995), some studies (e.g., Silberstein & Parsons, 1979) have shown alcoholic women to have milder cognitive deficits than do alcoholic men. It was recently reported that alcoholic women exhibit less severe impairments in balance and gait (Sullivan, Fama, Rosenbloom, & Pfefferbaum, 2002) and execution of smooth limb movement (Sullivan, Desmond, Lim, & Pfefferbaum, 2002) than do alcoholic men. An epidemiological study in a large community sample of older adults reported that, after age, education, depressive symptoms, and smoking status were controlled for, women who drank more than two drinks a day performed better on neuropsychological tests than women who did not (Du-

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fouil, Ducimetiere, & Alperovitch, 1997). In contrast, social drinking and cognitive function were not related in men.

In a study of a wide range of cognitive functions in alcoholic women who were abstinent on average for 3 months, we found that visuospatial abilities, verbal and nonverbal working memory, and gait and standing balance were significantly affected (Sullivan, Fama, et al., 2002). Executive functions, long-term declarative memory, and upper-limb strength and speed, however, were relatively spared. The deficits identified were largely consistent with those reported in the few other studies of alcoholic women, typically tested within a month of sobriety (Hochla & Parsons, 1982; Nixon & Glenn, 1995; Parsons, Butters, & Nathan, 1987; Sparadeo, Zwick, & Butters, 1983; Turner & Parsons, 1988), and also in studies of men (for reviews, see Kleinknecht & Goldstein, 1972; Oscar-Berman, 2000; Oscar-Berman & Hutner, 1993; Parsons et al., 1987; Sullivan, 2000). Our observation that these deficits persist in women, even after several months of sobriety, raised the question of whether the deficits are permanent or whether additional sobriety would eventually lead to further or even complete recovery. In this longitudinal study, we focus on recovery of the specific functions found to be impaired at study entry in a sample of alcoholic women originally tested after an average of 3 months of sobriety (Sullivan, Fama, et al., 2002). Women were retested on average after 1 and 4 years. A control sample was also retested after 3 years. Thus, this study is an initial attempt to identify which functions recover early, which recover late, and which deficits, if any, are likely to endure and possibly prove permanent, even with extended sobriety in alcoholic women.

Method

Participants

All participants gave written informed consent after the nature of the study and procedures were fully explained to them. Participants received a modest stipend for their involvement.

Alcoholic women. The original sample included 43 alcoholic women (age range = 28–63 years) recruited from inpatient and outpatient programs at a Veterans Administration Medical Center, outpatient programs at a university medical center, and community treatment programs. Potential participants, who gave consent, were initially screened by examination of treatment records, if available, followed by a phone interview. Those who passed the initial screening process came to the laboratory for a detailed clinical assessment that included a medical history, physical examination, electrocardiogram, clinical blood panel, and structured psychiatric interview (Structured Clinical Interview for the *DSM–IV*; SCID; First, Spitzer, Gibbon, & Williams, 1995). Participants were excluded if they had ever met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM–IV*) criteria (American Psychiatric Association, 1994) for schizophrenia or bipolar disorder; if they had a history of liver disease, medical or neurological illness, or trauma; if they had suffered a head injury involving loss of consciousness for more than 30 min; or if they were currently taking medications or illicit drugs that would affect the central nervous system (CNS).

Participants were not excluded for other lifetime Axis I comorbidities, and of the 43 alcoholic women, only 11 were free of such comorbidities. Nine had met criteria for only one other Axis I *DSM–IV* diagnosis (depression, panic disorder, posttraumatic stress disorder, dysthymia, or substance dependence); the rest had met criteria for two or more other Axis I *DSM–IV* diagnoses. The most frequent comorbidities were depression (n = 12), cocaine abuse or dependence (n = 8), cannabis abuse or dependence (n = 7), and polysubstance dependence (n = 4). Current depression symptoms were measured with the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996) at the time of neuropsychological assessment.

Total lifetime alcohol consumption was assessed with a structured interview (Skinner, 1982; Skinner & Sheu, 1982) that documented quantity of drinking (how many drinks per day) and frequency of drinking (how many drinking days per month) during successive drinking periods since the participant first began drinking regularly (at least one drink per month). Drinks of each type of alcoholic beverage (wine, beer, and spirit) were standardized to units containing approximately 13.6 g of absolute alcohol and summed over the lifetime (Pfefferbaum, Rosenbloom, Crusan, & Jernigan, 1988). Participants were tested on an outpatient basis after periods of sobriety ranging from 2 to 15 months (M = 3.6 months). Table 1 lists clinical and demographic characteristics of all alcoholic women initially entering the study.

Control women. A group of 47 control women (see Table 1) had previously been recruited to provide age norms for brain structure and cognitive and motor performance in studies of neuropsychiatric illnesses with incidence spanning the adult age range (20–85 years; Cahn-Weiner et al., 1999; Fama et al., 1997; Pfefferbaum, Rosenbloom, Deshmukh, & Sullivan, 2001; Sullivan, Fama, et al., 2002; Sullivan, Rosenbloom, Serventi, & Pfefferbaum, 2004). All participants had been screened with the SCID, a medical history, and a physical examination. They were excluded if they had a history of medical or neurological illness or trauma that could affect the CNS; had ever met either *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed., rev.; American Psychiatric Association, 1987) or *DSM–IV* criteria for a major psychiatric disorder, including substance dependence or substance abuse in the past year; or had reported a period of time lasting more than 1 month when they had drank more than two

Table 1
Participant Group Characteristics

Characteristic	Control (n = 47)		Alcoholic (n = 43)		
	M	*SD*	*M*	*SD*	*t* test *p*
Age (years)	54.5	17.3	42.1	9.5	.0001
Education (years)	15.6	2.0	14.7	3.2	*ns*
Handedness score[a]	17.5	4.4	21.7	14.7	*ns*
NART IQ	115.3	5.5	110.0	8.5	.001
Beck Depression Index[b]	2.2	2.6	10.2	8.9	.0001
Lifetime alcohol intake (kg)	34.2	54.7	521.6	364.3	.0001

Note. NART = National Adult Reading Test.
[a] A score of 14–32 indicates right-handedness. [b] The range of scores possible is 0–29; scores ≥ 14 indicate depressive symptoms.

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standard drinks each day. Lifetime alcohol consumption was assessed in the control participants with the same structured interview as with the alcoholic participants.

On average, the alcoholic women had consumed 15 times more alcohol during their lifetime than did the control women. As a group, the alcoholic women did not differ significantly in education or handedness (Crovitz & Zener, 1962) from the control women but had lower National Adult Reading Test (NART) IQ scores (an estimate of premorbid intelligence; Nelson, 1982) and higher BDI scores than control women. The mean age of the women in the control sample was greater than that of the alcoholic women; however, all performance scores were converted to age-corrected *Z* scores for each test (see below) before group comparisons were made.

Alcoholic women follow-up. Of the original 43 alcoholic women entering the study, 23 were retested about 1 year after the initial test ($M = 13.5$ months, range = 10–20 months), and 14 about 4 years after the initial test ($M = 46.5$ months, range = 35–71 months). At each follow-up, the SCID was readministered to document current diagnostic status including emergence of any new comorbidity since the last assessment. The structured alcohol consumption interview was readministered to document quantity and frequency of drinking since the last assessment and length of current sobriety.

Of the 43 subjects initially tested, contact was lost with 6. A 1-year follow-up was attempted for the remaining 37 and was completed for 23. Attrition was due to ongoing cancer treatment ($n = 1$), relocation ($n = 1$), refusal ($n = 3$), failure to return phone calls or keep scheduled appointment ($n = 6$), lack of cooperation during testing ($n = 2$), and post hoc exclusion from follow-up on the basis of an abnormal magnetic resonance image reading ($n = 1$).

The "4-year" follow-up occurred at intervals ranging from 3 to 6 years from initial test. Attrition from the 23 subjects completing a 1-year follow-up was due to death ($n = 3$), relocation ($n = 1$), lost contact ($n = 5$), refusal ($n = 1$), or scheduling difficulties ($n = 2$). An additional 3 participants who had not been available for the 1-year follow-up were located and completed the 4-year follow-up for a total sample of 14. Clinical and demographic descriptors of returning and nonreturning alcoholic women are provided in Table 2.

Control women follow-up. About 3 years ($M = 38$ months, range = 27–55 months) after initial testing, 14 women within the same age range as the alcoholic women were contacted for follow-up testing. Demographic descriptors of returning control women are provided in Table 2.

Neuropsychological Tests

Participants were given a similar neuropsychological test battery at each test occasion, although not all participants completed all tests on every occasion. The initial protocol included standard and experimental neuropsychological tests, which assessed specific component processes of cognitive and motor abilities of six cognitive and motor domains: executive functions, short-term memory and fluency, declarative memory, visuospatial abilities, upper-limb motor ability, and postural stability (Sullivan, Rosenbloom, & Pfefferbaum, 2000; Sullivan, Shear, Zipursky, Sagar, & Pfefferbaum, 1994). Alcoholic women participating in the follow-up study were significantly impaired at initial test relative to control participants in the following tests, which are grouped by functional domain.

Short-term memory. Short-term memory was assessed with distractor tests (Sullivan, Corkin, & Growdon, 1986) in which memoranda consisted of letter consonant trigrams in the verbal form and block triplets in the nonverbal form. Retention intervals were 0, 3, 9, and 15 s and were filled with a verbal (serial 3-s) distractor in the verbal task and a nonverbal (finger phalanx matching) distractor in the nonverbal task. The Memory subscale of the Dementia Rating Scale (DRS; Mattis, 1988) provided a broad-based assessment of memory status.

Visuospatial abilities. The Wechsler Adult Intelligence Scale (WAIS) Digit Symbol subtest (Wechsler, 1981) allotted 90 s for a participant to fill empty boxes with a symbol associated with each of the nine single-digit numbers. The score was the number of boxes correctly completed.

Gait and balance. Gait and standing balance were assessed with the walk-a-line ataxia battery (Fregly, Graybiel, & Smith, 1972), which con-

Table 2
Baseline Clinical and Demographic Descriptors and Alcohol Use for Returners, Nonreturners, Abstainers, and Relapsers

	1-year returners vs. nonreturners				1-year returners: Abstainers vs. relapsers				4-year returners: Alcoholic vs. control participants			
	Returner ($n = 23$)		Nonreturner ($n = 20$)		Abstainer ($n = 14$)		Relapser ($n = 9$)		Alcoholic ($n = 14$)		Control ($n = 14$)	
Descriptor	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Baseline clinical and demographic descriptors												
Age (years)	40.74	8.66	43.71	10.43	41.30	8.70	39.91	9.01	41.45	11.64	48.06	13.41
Education (years)	14.19	1.90	15.29	4.20	14.40	2.10	13.90	1.70	13.97	1.67*	15.61	1.74
Crovitz handedness score[a]	23.39	16.91	19.94	11.85	24.70	19.00	21.40	13.80	26.18	17.94	17.75	4.84
NART IQ	111.21	6.56	108.59	10.25	111.60	5.40	110.60	8.40	111.68	9.15	114.11	7.62
Beck Depression Index[b]	11.17	9.37	9.09	8.54	9.00	6.70	14.60	12.10	10.82	5.90**	1.69	2.16
Number comorbid for substance abuse/dependence	12		10		6		6					
Alcohol use at baseline												
Lifetime alcohol intake (kg)	500.21	362.17	550.63	376.32	411.40	353.40	638.30	350.00	496.20	368.80**	35.45	72.70
Length sober (months)	4.06	3.58	3.10	2.14	4.46	2.32	3.31	5.36	19.97	84.36		
Alcohol use at follow-up												
Alcohol intake since baseline (kg)					0**		15.50	4.00	14.50	5.80		
Length sober (months) at follow-up					18.10	4.80**	3.50	3.30	44.60	18.00		

Note. NART = National Adult Reading Test. Unpaired *t* tests: * $p < .05$; ** $p < .001$.
[a] A score of 14–32 indicates right-handedness. [b] The range of scores possible is 0–29; scores ≥ 14 indicate depressive symptoms.

sisted of three parts, each performed first with eyes open and then with eyes closed. First, the participant stood with feet placed heel to toe with arms folded across the chest for 60-s trials (stand heel-to-toe). Next, the participant stood on one foot for 30-s trials (stand on one foot). Finally, the participant walked heel-to-toe for 10 steps (walk heel-to-toe). Each condition was performed twice unless the participant achieved a perfect score on the initial trial. For this analysis, only scores from the more challenging eyes-closed condition were used.

Statistical Analysis

To normalize for effects of age and to place performance on all tests on a common scale, we converted scores for each test and each test occasion for alcoholic women to age-corrected *Z* scores using all available data from a sample of healthy women (Sullivan, Fama, et al., 2002). The number and age of control participants providing norms for each test varied as additional tests were added to the protocol over the study period, and not all participants completed all tests (see Table 3). The *Z* score for each participant represented her amount of deviation from norms for her age. By definition, the mean *Z* score of each test for control participants was 0 ± 1 *SD*. For the alcoholic women, mean *Z* scores represented the extent of disease-related impairment on that test for the group as a whole, after the effects of normal age had been statistically removed. Because we were seeking evidence of improvement with sobriety, we analyzed only those tests on which initial mean *Z* scores for the returning alcoholic women were -0.5 *SD* or worse, that is, those on which the returning alcoholic women as a group fell more than one half of a standard deviation below age norms.

Test scores for alcoholic women at the first (1-year) and second (4-year) follow-ups were also expressed as *Z* scores with the same normative data. This approach placed performance at initial test and at each follow-up on the same age-adjusted scale, enabling comparison between control and alcoholic groups at each test occasion. We hypothesized that alcoholic women's performance on tests showing abnormality initially would improve significantly, possibly to control levels, with increasing length of sobriety.

Short-term improvement was assessed by examining performance in 23 alcoholic women at the 1-year follow-up. Because data were not available from the control participants for a 1-year follow-up, change in 1-year performance for the alcoholic women was assessed in two ways. We compared each woman's initial performance with her 1-year follow-up performance (paired *t* tests) to identify any tests with a significant difference that would suggest improvement. We also compared 1-year follow-up scores with control data (unpaired *t* tests) to identify tests on which significant differences still persisted.

Longer term improvement was assessed in the 14 women who returned for the 4-year follow-up, 11 of whom had also been tested at the 1-year follow-up. Longer term follow-up data were also available from 14 control women for this analysis. A two-group repeated measures analysis of variance (ANOVA; 2 groups $\times$ 2 test times) of *Z* scores controlled for aging and practice effects in recovery. Group $\times$ Time interactions were predicted, indicating convergence of alcohol and control performance after extended sobriety. A one-group repeated measures ANOVA was also performed for the 11 alcoholic women for whom initial, 1-year, and 4-year scores were available. Finally, to examine the potential effects of relevant clinical variables on initial performance and change in performance, we correlated NART IQ, BDI scores, and alcohol use variables with the initial and change test scores using Pearson or Spearman correlation tests, depending on the distribution characteristics of the variables examined.

Results

To optimize the chance for detecting patterns of recovery and to minimize the chance of committing Type I or II errors in our relatively small samples, we selected for analysis only those tests on which the returning alcoholic women had been significantly impaired initially relative to the control participants. These included the verbal and nonverbal short-term memory distractor tests (total score); Memory subscale of the DRS; Digit Symbol subtest of the WAIS; and eyes-closed scores for the stand heel-to-toe, stand on one foot (average of left and right), and walk heel-to-toe tests.

Drinking Outcomes at Follow-Up

Abstainers were defined as those completely sober, and *relapsers* were defined as those who reported taking even one drink between initial and follow-up test sessions. At the 1-year follow-up, 14 of the 23 participants were classified as abstainers. One of the 9 relapsers started heavy drinking shortly after completing initial testing (total alcohol consumption of 90 kg or approximately 660 drinks) but had maintained sobriety for 76 days prior to follow-up testing. The remaining 8 relapsers drank moderately, with a mean total alcohol consumption throughout the intervening period of approximately 45 drinks. At the 4-year follow-up, 6 of the 14 women retested had maintained sobriety since initial testing (mean duration of 52.3 months), 7 women had relapsed at least

Table 3
Mean and Standard Deviation Z Scores at Baseline and 1-Year Follow-Up for 23 Alcoholic Women

Cognitive and motor variables	Control sample			Baseline					1-year follow-up				
	Size	Age (years) *M*	Age (years) *SD*	*M Z* score	*SD*	*t*	*df*	*p*	*M Z* score	*SD*	*t*	*df*	*p*
Verbal short-term memory	35	52	16	−0.63	0.81	2.69	56	.01	−0.91	1.23	3.12	56	.003
Nonverbal short-term memory	35	52	17	−0.92	1.17	3.31	55	.002	−0.83	1.73	2.30	55	.03
DRS Memory	28	50	18	−1.24	1.30	3.91	47	.0003	−0.95	1.53	2.67	48	.01
Digit Symbol	45	55	17	−0.52	0.94	2.22	65	.03	−0.71	1.32	2.51	66	.01
Stand heel-to-toe	26	49	18	−0.56	1.10	1.99	47	.05	−0.26	1.26	0.80	47	.43
Walk heel-to-toe	26	49	18	−0.48	0.73	2.09	47	.04	−0.43	0.90	1.58	47	.12
Stand on one foot	26	49	18	−0.79	0.79	3.47	46	.001	−0.74	0.91	2.95	47	.005

Note. Unpaired *t* tests compared alcoholic participants with all control participants from whom age norms were derived. *Z* scores for each test are based on regression analysis from control samples of the size and age range indicated. DRS = Dementia Rating Scale.

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once since initial testing but since the relapse had maintained sobriety for over 30 months prior to the 4-year follow-up (mean duration of 44.1 months), and only 1 woman had continued intermittent moderate drinking.

Comparison Between Returners and Nonreturners at Initial Testing

The high attrition rate for this study raises legitimate concerns that only women who were better educated, less depressed, consumed fewer other drugs, drank less heavily, and scored better on behavioral tests would return for follow-up, thus mitigating against finding residual impairment. Nonetheless, one-tailed *t* tests comparing 1-year returners to nonreturners found no significant differences in age, BDI score, handedness, years of education, NART IQ, or total lifetime alcohol consumption (see Table 2). Returners, however, performed significantly better than nonreturners on the verbal short-term memory test, $t(35) = 1.94$, $p = .03$. The even more select group of 4-year returners were also demographically comparable with 4-year nonreturners and did not differ from nonreturners on any initial neuropsychological tests. Other sources of bias in the attrition rate, such as substance abuse or dependence comorbidity, were also not forthcoming, as women with substance abuse or dependence were as likely to participate in follow-up ($n = 12$ of 22) as those without substance comorbidities ($n = 11$ of 21). Substance abusing women were significantly younger (36 ± 6 years) than nonsubstance abusing women (45 ± 12 years), $t(41) = 2.15$, $p < .05$, but were not significantly more impaired relative to age norms on any of the tests studied, with the exception of a trend noted for the stand on one foot test, $t(35) = 1.86$, $p = .07$.

Alcoholic Performance at Initial Testing and 1-Year Follow-Up

Paired *t* tests comparing initial and 1-year follow-up scores for the 23 alcoholic women revealed no significant difference between test occasions. Furthermore, alcoholic women's performance at the 1-year follow-up remained significantly lower than age norms for all tests but stand heel-to-toe and walk heel-to-toe (see Table 3).

Contribution of Drinking to Change at 1-Year Follow-Up

Of the 23 women retested at the 1-year follow-up, 14 had remained sober and 9 had relapsed to some level of drinking. Abstainers and relapsers did not differ at a statistically significant level initially on age, NART IQ, years of education, BDI, handedness, lifetime alcohol consumption (see Table 2), or performance on any of the cognitive and motor tests. They also did not differ statistically in performance on any cognitive or motor test at the 1-year follow-up. In addition, Spearman correlations between the amount of alcohol consumed over the follow-up period with performance change did not reveal any consistent relationship between these variables.

Change With Extended Sobriety: 4-Year Follow-Up

Eleven of the alcoholic women in the 1-year follow-up sample along with 3 alcoholic women unavailable for 1-year follow-up returned for the 4-year follow-up. All but 1 of these women had maintained substantial periods of sobriety at time of testing ($M = 44.6$, range = 6–72 months). One woman had been drinking more recently and consumed approximately 29 kg alcohol in the 3-year interval between initial test and her 4-year follow-up. She was included in the analyses reported below, as the results were essentially the same with or without her. At initial testing, this subgroup of participants had been significantly impaired relative to age norms on the DRS Memory test, $t(39) = 3.85$, $p = .0004$, the nonverbal short-term memory test, $t(45) = 2.42$, $p = .02$, and the stand on one foot test, $t(38) = 2.14$, $p = .04$, and showed impairments approaching significance on the verbal short-term memory test, $t(46) = 1.80$, $p = .08$, and the Digit Symbol test, $t(57) = 1.95$, $p = .056$. By contrast, they had performed within age norms initially for the stand heel-to-toe test, $t(38) = 1.33$, $p = .19$, and the walk heel-to-toe test, $t(38) = 0.83$, $p = .41$.

Of the 47 control women, 14 were recalled for testing 3 years after initial testing. Their initial and retest data were entered into a two-group repeated measures ANOVA with initial test and 4-year follow-up data from 14 alcoholic women. This analysis yielded significant Group × Time interactions for the DRS Memory test, the nonverbal short-term memory test, and the Digit Symbol subtest of the WAIS. Parsing of interactions showed that alcoholic women improved significantly between initial and 4-year retest on these tests, whereas control participants made no significant change. Stand heel-to-toe and walk heel-to-toe, normal at initial testing for this subgroup, did not change at the 4-year follow-up. Verbal short-term memory showed some improvement but not enough to yield a significant interaction. Initial impairment in stand on one foot showed no signs of improvement. These analyses with ANOVA interaction terms are illustrated in Figure 1.

Within-group repeated measures ANOVAs comparing *Z* scores for the alcoholic women who had participated in all three test occasions (initial, 1-year, and 4-year) yielded significant time effects only for verbal and nonverbal short-term memory. For verbal short-term memory, this was due to reduction in performance at the 1-year follow-up followed by return to initial levels at the 4-year follow-up. For nonverbal short-term memory, this was due to improvement between the 1-year and 4-year follow-up test times (see Figure 2).

Analysis of Slopes

Because intervals between baseline and 1-year (range = 10–20 months) test occasions and between baseline and 4-year (range = 35–71 months) test occasions were quite variable across participants, we calculated slopes, the amount of change divided by individual intervals, for each test for each alcoholic woman. One-group *t* tests of these slope values yielded a pattern of results consistent with those based on ANOVA and *t* tests of performance at each test occasion.

Predictors of Recovery and Covariates

NART IQ, BDI scores, and lifetime alcohol use at initial testing were tested as predictors of cognitive and motor change over the 4-year follow-up period. Spearman correlations failed to yield any significant relationships.

Analysis of covariation (ANCOVA) to control for group differences in estimates of premorbid IQ determined that significant

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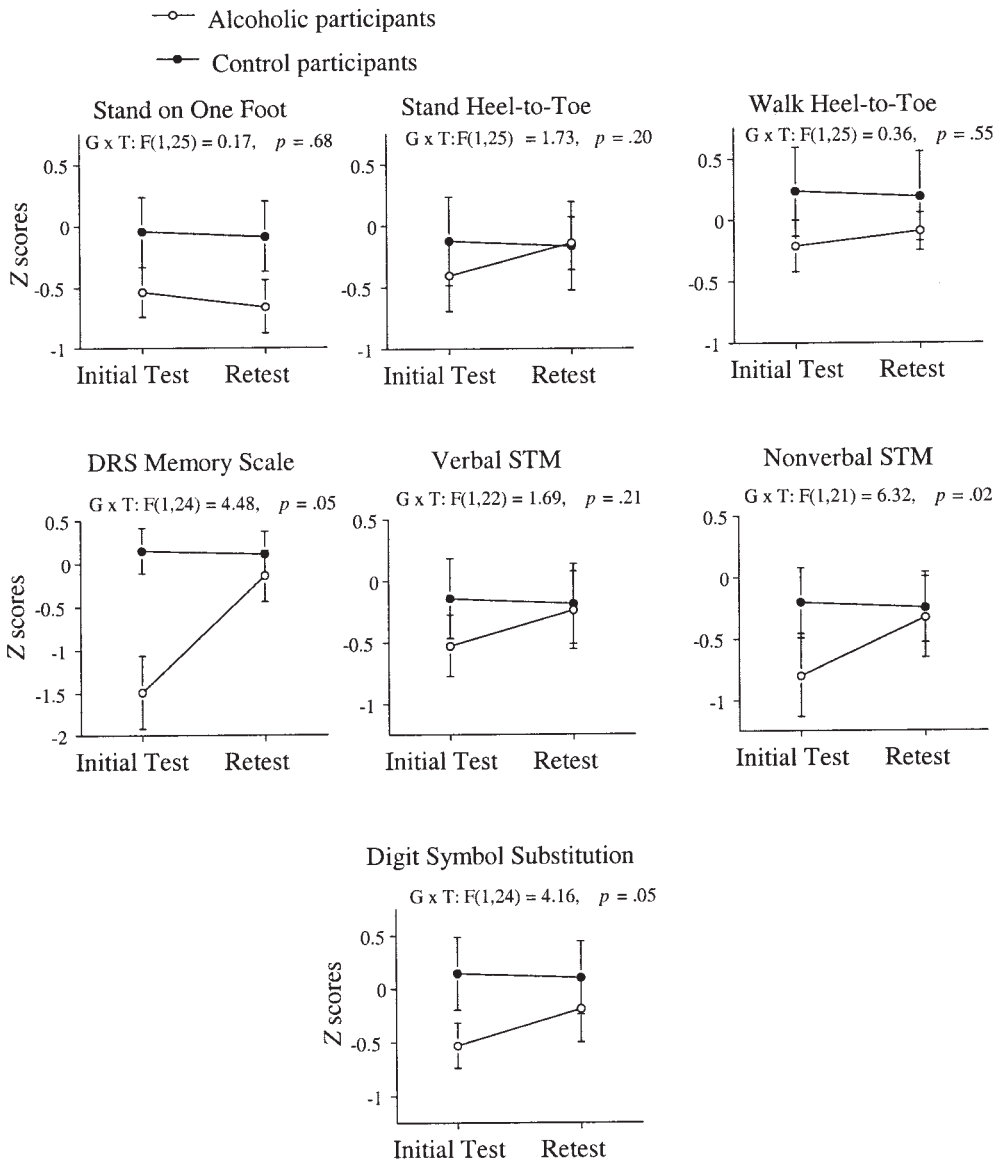

Figure 1. Initial test and 4-year follow-up *Z* scores for 14 alcoholic women and 14 control women for motor (top row), memory (middle row), and psychomotor (bottom row) tests. Analysis of variance interaction (Group × Time; G × T) terms were significant for the Dementia Rating Scale (DRS) Memory, nonverbal short-term memory (STM), and Digit Symbol tests. Deficits in the stand on one foot test persisted despite extended sobriety. Participants were not impaired on the stand heel-to-toe and walk heel-to-toe tests at initial test and showed relatively little change over the follow-up interval. Error bars indicate standard errors of the mean.

initial group differences persisted in all tests after accounting for the lower NART IQ in the alcoholic women. ANCOVA using BDI as a covariate to control for group differences in depressive symptoms revealed that significant group differences in performance on all tests but stand-heel-to-toe ($p = .08$) and walk-heel-to-toe ($p = .10$) persisted.

Discussion

This longitudinal study focused on determining whether the cognitive and motor deficits observed in a group of alcoholic women initially tested after an average of 3 months of sobriety would show any recovery after longer periods of sobriety. Although the attrition rate was high and sample sizes modest, the returners did not differ significantly from nonreturners in demographic variables or initial testing performance. A substantial number of the alcoholic participants remaining in the study had maintained sobriety since their initial assessment, and even those who had relapsed reported relatively low levels of drinking. Even so, few significant improvements were noted after about 1 year, whether or not sobriety had been maintained.

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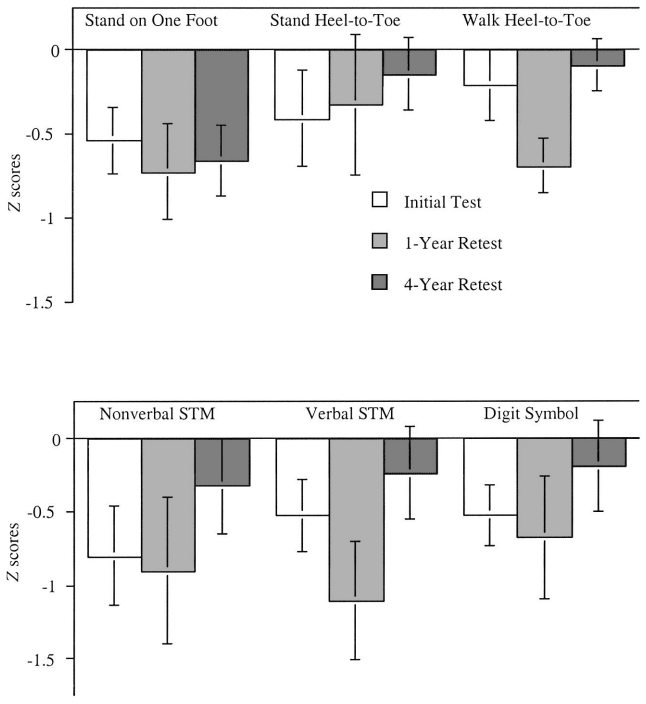

Figure 2. *Z* scores (means and standard errors) for motor (top) and cognitive (bottom) tests for the subgroup of alcoholic women who participated at initial (n = 14), 1-year (n = 11), and 4-year (n = 14) test occasions. The zero line represents age norms for each test. Negative *Z* scores represent performance that is below normal for age. STM = short-term memory.

However, after 4 years of sobriety, improvements in overall memory, nonverbal short-term memory, and psychomotor speed were noted, but deficits in a challenging test of postural stability, standing on one foot, persisted.

The lack of significant cognitive recovery at 1 year in the alcoholic women, even for those who remained abstinent, is consistent with much of the existing literature. For example, both cross-sectional and test–retest studies using the Digit Symbol test report similar findings to ours for women (Fabian & Parsons, 1983; Hochla et al., 1982), men (Brandt et al., 1983; Reed et al., 1992; Yohman et al., 1985), and mixed-gender groups (Parsons et al., 1990). A composite neuropsychological efficiency measure failed to show clear evidence of recovery with 14-months abstinence in a test–retest study with a mixed-gender sample (Glenn et al., 1994; Parsons et al., 1990). Likewise, short-term memory was not significantly different in alcoholic men who were sober from 1 to 2 months and those who were sober on average for 2 years (Brandt et al., 1983; Reed et al., 1992). By contrast, cross-sectional studies of alcoholics who have been sober for longer (more than 4 years) consistently report performance at normal levels on tests of learning and memory (Brandt et al., 1983; Grant et al., 1984; Reed et al., 1992; Rourke & Grant, 1999). Tests of balance and gait have not previously been featured in studies dealing with recovery in alcoholic women, either with cross-sectional or longitudinal designs.

As a naturalistic study, the design of the current study provided no control over drinking behavior and was prone to the bias of selective attrition. Indeed, the limitations of a high attrition rate, variable retest intervals, and variable lengths of sobriety relate to the realities of recruiting, testing, and following up alcoholic women in a health care environment where substance abuse is treated on an outpatient basis and by self-help rather than through highly structured 1-, 3-, or even 6-month inpatient programs. Only 23 of the original sample of 43 were retested at the 1-year follow-up, and the 4-year follow-up sample declined to 14. Our 1-year retention rate of 43% is better than the 32% reported for a 2-year follow-up study focusing exclusively on alcoholic women (Fabian & Parsons, 1983), comparable with the 51% reported for a 1-year follow-up of alcoholic men (Yohman et al., 1985), but not so good as the 70% reported for men (Rourke & Grant, 1999) and mixed-gender (Glenn et al., 1994) alcoholic samples. Nevertheless, 1- and 4-year returners did not differ in age, intelligence, years of education, handedness, lifetime level of alcohol consumption, depressed mood, or substance comorbidity from those lost to follow-up. Furthermore, initial cognitive and motor performance of the 1-year returners was comparable with that of nonreturners on all but verbal short-term memory, whereas the 4-year returners were comparable with nonreturners on all tests. Although group differences between returners and nonreturners were not significant, returners, especially those for the 4-year follow-up, tended to have higher scores on most tests than did nonreturners and were closer to age norms on tests of posture and gait at initial testing. Thus, the possibility that the improvements with sobriety seen in these women were presaged by higher initial function cannot be dismissed.

The lack of control data for the 1-year follow-up precluded our ability to formally evaluate practice effects over this interval. That the alcoholic women did not benefit from any nonspecific experiential factors associated with returning to repeat a series of tests is perhaps additional testimony to their failure to recover. It is possible, however, that the 1-year follow-up session provided alcoholic women with the benefit of a practice effect relative to control participants at the 4-year follow-up session. However, the comparable mean interval between 1-year and 4-year follow-up for alcoholic women (32 $\pm$ 12 months) and between initial test and 4-year follow-up for control participants (38 $\pm$ 9 months) eliminated any strong recency advantage to the alcoholic women.

Although some of the nonreturners were lost because they had relocated or died, it is possible that others were difficult to track or unwilling to participate in follow-up because they had returned to heavy levels of drinking. By contrast, only one 1-year returning participant reported substantial levels of interim drinking. Indeed, more than 50% of the 1-year returners reported complete sobriety at the 1-year retest, whereas the mean length of sobriety for the 4-year returners was 44 months, with only 1 participant reporting recent alcohol use. Thus, this study, unlike an earlier study of alcoholic men (Sullivan, Rosenbloom, Lim, & Pfefferbaum, 2000), did not provide a clear distinction in quantities of alcohol consumed between relapsers and abstainers, and consequently we found no meaningful 1-year differences in cognitive recovery between relapsers and abstainers. These observations are limited by our reliance on self-report for interim drinking.

The alcoholic women experienced significantly greater comorbidity for depression than did control women, who were screened to exclude those with any other Axis I psychiatric diagnosis. Comorbidity with depression is a prominent feature of alcoholism

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in women, but current depressed mood did not account for the alcoholic women's lower cognitive performance at initial test. However, it may have contributed to lower initial test performance on the stand heel-to-toe and walk heel-to-toe tests. Changes in depressed mood over the follow-up period were not related to cognitive or motor recovery. Nor did initial levels of depression predict levels of performance or amount of recovery in the alcoholic women. Among other predictors of recovery that we found nonsignificant were prior drinking history and premorbid intelligence. These observations must not be considered definitive given the relatively small sample size in this study and level of attrition.

Improvements in nonverbal short-term memory and Digit Symbol test performance after extended sobriety may be related to long-term changes in brain structures subserving these functions. In an earlier study, alcoholic men were retested 3–12 months after discharge from a 30-day treatment program. At retest, clear distinctions in cognition had emerged between abstainers and resumers, and we found associations between composite measures of balance and gait and measures of anterior superior vermis on the one hand and between composite measures of short term memory and third ventricle volume on the other (Sullivan, Rosenbloom, Lim, & Pfefferbaum, 2000). We can only speculate that similar associations occur in women.

In summary, this study focused on specific cognitive and motor tests for the sample of alcoholic women who, on initial testing, had shown persistent deficits (even after an average of 3 months of sobriety) relative to age norms. Furthermore, the naturalistic character of the study directed our analysis toward the effects of extended sobriety. The results provide encouraging evidence that women who have been alcohol dependent and suffered cognitive and motor deficits can experience improvement with long-term cessation of alcohol drinking in some functions, most notably nonverbal short-term memory and psychomotor speed, but carry a persisting liability for postural instability.

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