

# Language-Enriched Exercise Plus Socialization Slows Cognitive Decline in Alzheimer's Disease

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This article reports the effects of language-enriched physical fitness interventions provided by University of Arizona undergraduate students to 24 mild- to moderate-stage Alzheimer's disease patients (AD Rehab group). Socialization experiences consisted of supervised volunteer work and cultural/recreational activities. Changes in global functioning and neuropsychological test performance were tracked and compared to those of a similar group of untreated patients from the Consortium for the Establishment of a Registry for Alzheimer's Disease (CERAD). Cohorts completing 4 semesters or longer showed no significant between-year changes after their

first year on the Clinical Dementia Rating, a measure of global functioning, and on 5 or 6 of the cognitive and language measures. Comparisons with the CERAD sample suggested a slower rate of decline for the AD Rehab group. The stabilization of global and cognitive performance was not apparent among participants who completed only 2 semesters. Significant physical fitness and mood outcomes were previously reported in this journal.

**Keywords:** Alzheimer's disease; rehabilitation; cognitive training; language training; CERAD; cognitive decline

## Objectives

Studies of longitudinal nonpharmacological interventions with community-dwelling Alzheimer's disease (AD) patients are rare. Drug studies, while numerous, focus on treatment outcomes and do not provide an ongoing rehabilitative process. This study had the multiple objectives of slowing global decline and providing an intervention that would increase social involvement and improve physical fitness and mood in patients with mild to moderate AD. It further aimed to demonstrate the viability of using undergraduate students to deliver the interventions.

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## Rationale for Exercise Intervention

The general benefits of exercise for maintaining brain health and in reducing risk for diseases of aging have been widely reported.<sup>1,2</sup> Recent studies in Canada<sup>3</sup> and the United States<sup>4</sup> found that people who were physically active had a significantly lower risk of developing AD than people who were inactive.

A study of 6000 women older than 65 years that tracked subjects' physical activity habits for 8 years found that women who walked the most were least likely to show cognitive decline.<sup>5</sup> Two very recent studies published in the *Journal of the American Medical Association*, involving more than 18 000 elderly women<sup>6</sup> and 2257 men,<sup>7</sup> replicated that study's results. Most relevant, a randomized controlled trial of a caregiver-administered exercise plus behavioral management intervention significantly improved mood and physical functioning in AD patients.<sup>8</sup>

Research has found several mechanisms that may be responsible for the cognitive benefits of exercise. In several animal studies, it was found that running fostered neurogenesis and learning in mice.<sup>9</sup> Cotman and Engesser-Cesar<sup>10</sup> found that wheel-running mice had an increase in brain-derived neurotrophic factor, a

molecule that fosters learning and protects neurons against degeneration that leads to cognitive decline. Other researchers have found that people who experience “silent strokes” more than double their risk of developing dementia, so that exercise and other steps that contribute to vascular health and increase blood flow to the brain can reduce the risk of developing AD.<sup>11</sup>

Finally, recent research demonstrated that long-term physical activity<sup>12</sup> and such activity plus a social and stimulating environment enhanced the learning ability of mice and decreased the level of plaque-forming  $\beta$ -amyloid protein fragments.<sup>13</sup>

## Rationale for Cognitive/Social Intervention and Combined Activities

When the AD Rehab study was designed, there were no published studies of cognitive interventions in combination with exercise for persons with AD, and other than the present one, there still is none. However, recently published research on a biracial sample of 6158 persons older than 65 years reported an association between participation in cognitively stimulating activities and a lowered risk of developing AD.<sup>14</sup> Another recent study found that participation in leisure activities, such as board games, reading, dancing, and playing a musical instrument, was also correlated with reduced risk of AD.<sup>15</sup> Most recently, an epidemiological study at Johns Hopkins University<sup>16</sup> found that older adults who engaged in a wide variety of exercise and other activities were less likely to develop dementia. This finding was confirmed in recent animal research, which found that beagles provided with exercise, stimulating activities, and an antioxidant-enriched diet learned faster than dogs receiving standard care.<sup>17</sup>

Aside from the practical benefit of presenting cognitive-linguistic tasks to help pass the time during aerobic exercise, both animal and human research suggests that multiple or combined activities are more beneficial than a single activity. It stands to reason that this should be so for persons with dementia.

## Method

### Study Participants

Study participants were 24 individuals from Tucson, Arizona, who had been diagnosed with probable

AD according to criteria used in the Consortium for the Establishment of a Registry for Alzheimer’s Disease (CERAD) study. CERAD criteria correspond to those established by the National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer’s Disease and Related Disorders Association Work Group.<sup>18</sup> As in the CERAD study, participants were 50 years or older and English speaking. There were 2 early-onset participants (aged 54 and 59 years at entry); 11 were in their 70s, and 11 were in their 80s. The mean age of the participants was 78.8 years (SD = 8.04). Baseline Mini-Mental Status Examination (MMSE)<sup>19</sup> score ranged from 15 to 29 (Table 1). All participants and their caregivers provided signed informed consent in accordance with procedures approved by the University of Arizona Human Subjects Committee (Institutional Review Board).

### Screening Procedure

Persons who seemed eligible, based on written applications by caregivers or phone interviews with them, were interviewed and given a screening MMSE to see if they met basic project criteria and were willing to do all of the required activities. Most of these interviews were at the patient’s home. A simplified consent form, in addition to the official human subjects consent form that the caregiver read and signed, was read aloud—item by item—to the person with AD. During that screening session, if the applicant seemed suitable and willing, consent to obtain medical records was obtained. Then that form, plus a form explaining the physical fitness aspects of the program and requesting the physician to give either unqualified consent, consent with conditions, or nonconsent, was mailed or faxed to the applicant’s physician.

### Clinical and Neuropsychological Assessment

Stage of dementia was determined via the Clinical Dementia Rating (CDR),<sup>20,21</sup> a structured clinical interview with both the patient and caregiver. The CDR assesses 6 domains: (1) memory, (2) orientation, (3) judgment and problem solving, (4) community affairs, (5) home and hobbies, and (6) personal care. These are assigned a score and summed to yield a total score (Sum of Boxes) and are weighted to yield a stage of dementia score, with 0 = *no dementia*, 0.5 = *questionable*, 1 = *mild*, 2 = *moderate*, and 3 = *severe*.

**Table 1.** Participant Demographic Characteristics

Gender	Age*	MMSE†	Education	Residence	Primary Occupation	Prescription Drugs at Entry
4-Year completers						
F	84	26	12	Group home	Driver	None
F	86	29	12	Apartment/part-time caregiver	Small-business owner	Sulindac, metaprolol, Cardizen, amitriptyline
F	83	17	14	Assisted living	Homemaker	Synthroid, Claritin, Paxil
M	59	23	12	With spouse	Skilled tradesman	None
3-Year completers						
F	78	26	12	With relatives	Clerical, sales	Tamoxifen
F	82	15	18	Assisted living	Health professional	Premarin, Paxil
F	88	21	16	With son	Professional	Zestril
F‡	74	27	16	With spouse	Health professional	Accupril, Hydrin, Sulindac, Levoxyl
2-Year completers						
M	78	23	15	Group home	Musician	Buspar, Zoloft, Zocon
F	79	22	12	Home with relatives	Food service worker	Cosamin
F	78	18	10	Assisted living	Factory worker	Thyroid medication
F	83	23	12	Alone/group home	Office worker	None
F§	79	26	12	Assisted living	Salesperson	Zestril
1-Year completers						
M	85	29	12	With spouse	Farmer, maintenance worker	None
F	73	22	14	Home with caregiver	Homemaker/active volunteer	Cholesterol drug
M	79	20	16	With spouse	Maintenance supervisor	Glyburide, Naprosyn
F	79	22	11	Alone/family nearby	Clerical worker	Paxil, Premarin
M	88	22	12	Alone	Skilled tradesman	None
F	54	24	14	With spouse	Office worker	Diazide
F	80	28	12	Alone/relatives near	Postal worker	Aricept, <sup>¶</sup> Synthroid, Fosamax
M	84	20	10	With spouse	Skilled tradesman	Aricept
M	75	28	17	With spouse	Computer professional	Aricept, Paxil, Hytrin
M	78	29	12	With spouse	Skilled trade	Prozac, Testred, Synthroid, Claritin, hydrocortisone, Orybrytmen
F	85	22	10	With relatives	Skilled tradesperson	Aricept, Prozac

\*Age at entry.

†Folstein Mini-Mental State Examination score at entry.

‡Completed 7 semesters.

§Completed 5 semesters.

||Completed 3 semesters.

¶Subjects on Aricept accepted in final year of study, as drug-free Ss not found.

Seven of the CERAD neuropsychological battery's 8 subtests were administered: 60-Second Verbal Fluency (for the category animals); 15-Item Boston Naming, MMSE, Word List Memory, Constructional Praxis, Word List Recall, and Word List Recognition.

In addition, the following were given: the Geriatric Depression Scale<sup>22</sup> and the Picture Completion, Comprehension, and Similarities subtests of the Wechsler Adult Intelligence Test–Revised (WAIS-R).<sup>23</sup> None of the testers had any connection with the

interventions or any stake in the program's outcome. However, as there was not a no-treatment control group, testers were aware of the interventions. Administered to participants before beginning treatment, these tests were readministered annually.

### *Language Assessment*

On a separate testing occasion, participants were administered the Arizona Battery for Communication Disorders of Dementia.<sup>24</sup> This test consists of 14 subtests and assesses 5 constructs: mental status, episodic memory, linguistic expression, linguistic comprehension, and visuospatial construction. The 5 construct scores are summed to yield a total score.

Quality and quantity of discourse were assessed using 6 measures of performance on 8 prompt questions or stimuli, a picture description, and a proverb interpretation task. The development and analysis procedures are described elsewhere.<sup>25,26</sup> The discourse prompt questions are shown in Appendix A.

### *Neurological Examination*

All enrolled participants underwent a confirmatory diagnostic neurological examination by Bruce Coull, head of the University of Arizona's Department of Neurology.

### *Physical Fitness Assessment*

Aerobic fitness at entry was assessed by a 6-minute walk test, which measures the distance (in feet) a person can walk in 6 minutes. This is a commonly used and reliable measure of fitness in elderly and disabled persons.<sup>27</sup> Progress in duration of per-session aerobic exercise was also tracked. Upper and lower body strength was assessed by comparing the mean amount lifted during the first semester's sessions with the mean amount lifted in subsequent semesters.

### *Mood*

Mood was assessed prior to participation and at the end of each treatment semester by means of oral administration of the Geriatric Depression Scale.<sup>22</sup>

### **Intervention**

The intervention consisted of 20 physical fitness workouts per semester: 2 per week for 10 weeks. One session per week was enriched by a series of 8 to 10 language- and memory-stimulation activities

administered by students. The other 10 workouts—1 each week—were supervised by caregivers. In addition, participants experienced 10 weekly student-supervised community activity sessions, alternating between a volunteer service activity and a cultural or recreational event.

### *Physical Exercises*

The physical fitness session consisted of aerobics (treadmill and stationary bicycle), stretching and balance exercises, and 2 sets of 10 to 12 repetitions on 5 MedX weight resistance machines that focus on large muscle groups: leg press, chest press, overhead press, torso arm, and seated row. Everyone was started at 5 minutes on the treadmill and 5 minutes on the bike, with incremental increases as tolerated. The goal was 20 minutes of aerobics by the end of the first semester and 30 minutes by the end of the second. On the weight machines, repetitions were first increased from 10 to 12 at a given weight. When successfully accomplished, weight was increased, typically 2 lb at a time for upper body machines and 10 to 20 lb on the leg press. A detailed description of the exercise protocol has been published in this journal.<sup>28</sup>

### *Cognitive Interventions*

The language- and memory-stimulation activities administered provided practice in all of the important cognitive operations that have been identified as relevant to conversational performance<sup>29</sup> and that are typically compromised in persons with AD: attention, explicit memory, judgment and reasoning, planning, problem solving, set shifting, abstract reasoning, and semantic memory. Activities requiring deep concentration or attention to visual stimuli were administered during rest periods before, after, and between physical activities. Others involving quick back-and-forth repartee took place while the patients were on the treadmill or bike and helped pass the time and minimize boredom. The story recall task used was based on Arkin's effective memory training technique for teaching and reteaching personally significant facts to AD patients, which has been described in this journal and elsewhere.<sup>30-32</sup> Examples of each of the 14 activities used appear in Appendix B and on the Elder Rehab Web site ([www.u.arizona.edu/~sarkin/elderrehab.html](http://www.u.arizona.edu/~sarkin/elderrehab.html)). (The AD Rehab program was known in the community as Elder Rehab so as not to tag participants with an Alzheimer's label.) A resource manual containing examples of all 14 activities sufficient for 10 client

**Table 2.** Comparison of Alzheimer's Disease Rehab and CERAD Groups at Enrollment

	n	% Female	Age			MMSE		
			Mean	SD	Range	Mean	SD	Range
AD Rehab	24	67	78.8	8.0*	54-88	23.4	3.9	15-29
CERAD sample	245	60	75.5	7.7	54-88	20.5	3.1†	15-28

CERAD = Consortium for the Establishment of a Registry for Alzheimer's Disease.

\*AD Rehab group mean age significantly older than that of CERAD group.

†CERAD group mean Mini-Mental Status Examination score significantly lower than that of AD Rehab group.

sessions and a 60-minute video demonstrating the activities accompany the author's continuing education correspondence course package on language-enriched exercise for persons with AD.<sup>33</sup> An example of each is in Appendix B.

### Community Activities

The partnered volunteering aspect of the program grew out of clinical observations that AD patients tended to remember responsibilities they had for others better than their own affairs and that they felt good about themselves when they were able to be of service to others. It was also grounded in research evidence that life satisfaction in elderly persons is positively correlated with level of activity<sup>34</sup> and research documenting the physical and mental health benefits of volunteer work,<sup>35</sup> work therapy for dementia patients,<sup>36</sup> and socially involving activity.<sup>37,38</sup> Volunteer and recreational activities were selected according to the interests and skills of the patients. Students were instructed to incorporate 20 minutes of brisk walking into the community activity session to increase aerobic involvement to the 3 times per week minimum frequency recommended by most experts. Volunteer activities included reading to and playing with children at a child day care center, grooming and walking dogs and cleaning cat cages at the Tucson Humane Society, bagging bulk rice and beans and filling food boxes at the community food bank, taking nursing home residents for rides in their wheel chairs and participating in their group activities, picking up trash in public parks, and shelving and stamping in new books at a school library. (For a description of a therapeutic volunteer work program for AD patients operated by an adult day care center in Chicago, see the work by Stansell.<sup>39</sup>) Recreational activities included mall walking and window shopping; attendance at special AD Rehab-sponsored concerts for persons with dementia

and their caregivers; trips to museums, art galleries, antique shops, city parks, and the zoo; and rides on a paved trail in a "surrey" (a 4-wheeled canopied vehicle pedaled by 2 side-by-side cyclists that was loaned to the program by a local bicycle shop).

### Data Analysis

Between-year change scores for the AD Rehab participants (ie, baseline-year 1, year 1-year 2, etc) were analyzed using paired *t* tests. For the AD Rehab intervention to be successful, one would expect to see nonsignificant results on the paired *t* tests, which indicate whether observed change was different from zero. Zero change would correspond to stability of performance, in contrast to the pattern of decline one would expect from persons with a progressive dementia.

Dose response to intervention was measured by comparing between-year change scores of 4 subgroups of AD Rehab participants: those who completed 2 semesters of treatment (1-year completers), those who completed 4 semesters (2-year completers), those who completed 6 semesters (3-year completers), and those who completed 8 semesters (4-year completers). One-way ANOVA comparing the enrollment MMSE scores of the 4 subgroups showed no statistically significant differences ( $P < .05$ ) between them. When it was found that the 4-year completers ( $n = 4$ ) had the best outcomes, post hoc comparisons of the baseline characteristics of that cohort with those of the other 19 AD Rehab participants found no differences in age, years of education, number of comorbidities, or scores on the MMSE, Arizona Battery for Communication Disorders of Dementia (ABCD), and CDR (see Table 2).

Comparisons of a similar sample of CERAD participants and AD Rehab participants on selected



**Table 3.** AD Rehab Outcomes: 1-Year Completers

Test	Baseline Mean Scores (SD)	Year 1 Mean Scores (SD)	Mean Difference Scores (SD)
MMSE (n = 23)	23.4 (4.0)	20.5 (5.3)	-2.9 (3.6)*
CDR (n = 16)	1.2 (0.5)	1.53 (0.7)	0.33 (0.6)†
Sum of Boxes (n = 16)	7.5 (2.4)	9.1 (3.9)	1.6 (2.7)†
CERAD Verbal Fluency (Animals; n = 23)	9.5 (4.2)	9.0 (4.9)	-0.46 (3.2)
CERAD Boston Naming (15 Item; n = 23)	13.3 (1.9)	12.4 (3.1)	-0.87 (2.2)†
ABCD (n = 23)	18 (2.21)	17.1 (2.4)	-0.93 (1.37)*
WAIS-R Comprehension percentile scores (n = 22)	63.9 (23.7)	50.6 (35.0)	-13.3 (23.4)*
WAIS-R Similarities percentile scores (n = 22)	60.5 (33.2)	55 (32.3)	-7.4 (26)

MMSE = Mini-Mental Status Examination; CDR = Clinical Dementia Rating; CERAD = Consortium for the Establishment of a Registry for Alzheimer's Disease; ABCD = Arizona Battery for Communication Disorders of Dementia; WAIS-R = Wechsler Adult Intelligence Test-Revised.

\* $P < .01$ .

† $P < .05$ .

between-year change scores and trends over time in study were done using analysis of variance. For the AD Rehab intervention to be more successful, between-year change scores would be smaller and the trend over time for these participants would be less steeply sloped than those of the untreated CERAD participants.

The AD Rehab and CERAD groups were similarly compared as to age at enrollment, number of comorbidities, years of education, and pretreatment scores on the MMSE and Sum of Boxes. The AD Rehab group had a significantly older mean age (3.3 years), and the CERAD group had a significantly lower mean baseline MMSE score (-2.9 points) but were no different from the AD Rehab group on all of the other variables (see Table 2).

## Results

In May 2001, the AD Rehab program completed its fourth and final intervention year with 14 enrolled participants. During the 4 years, 24 individuals completed at least 1 year (2 or 3 semesters) of participation, 13 completed 2 years (4 or 5 semesters), 8 completed 3 years (6 or 7 semesters), and 4 completed 4 years (8 semesters). Test results reported were administered after completion of semesters 2, 4, 6, and 8. Results are reported according to length of participation, with persons completing a given number of years regarded as a cohort, irrespective of when they

entered the program. As will be seen, effects on global and cognitive functioning were most positive (no significant between-year decline on 5 or 6 tests) after 2 or more semesters of participation.

### Cognitive and Language Outcomes

Paired *t* tests were done to derive between-semester change scores for 8 of the standardized cognitive tests administered: MMSE, CDR, Sum of Boxes, Verbal Fluency, CERAD (15-Item) Boston Naming, ABCD, WAIS-R Comprehension, and WAIS-R Similarities. Significant annual decline in mental status, as measured by the MMSE, occurred for all cohorts except the 4-year completers; however, the decline, after the first year, was less than that of a similar CERAD group. (See the section on AD Rehab and CERAD comparisons.) The mean annual decline in scores on the MMSE was 2.9 points for the 1-year completers, 2.5 for the 2-year completers, 2.0 for the 3-year completers, and 1.0 for the 4-year completers.

Maintenance of function (ie, no significant between-year decline on 5 or 6 of the cognitive and language measures) occurred with cohorts that completed 2 or more years of participation.

The 1-year completers (n = 24) had no decline on only 2 measures: Verbal Fluency (Animals) and WAIS-R Similarities, between baseline and end of year 1 testing. See Table 3.

The 2-year completers (n = 13) showed no decline on 5 measures: the CDR, Sum of Boxes, Verbal

**Table 4.** AD Rehab Outcomes: 2-Year Completers

Test	Baseline	Year 1	Mean Difference	Year 2	Mean Difference	Mean Difference
	Mean Scores (SD)	Mean Scores (SD)	Scores Baseline-Year 1 (SD)	Mean Scores (SD)	Scores Year 1-Year 2 (SD)	Scores Baseline-Year 2 (SD)
MMSE (n = 13)	22.8 (4.2)	19.9 (5.5)	-2.8 (2.9)*	17.7 (5.7)	-2.2 (3.0)†	-5.1 (3.7)*
CDR (n = 8)	1.25 (0.46)	1.56 (0.82)	0.31 (0.60)	1.75 (0.89)	0.187 (0.75)	0.5 (0.76)
Sum of Boxes (n = 8)	7.25 (2.7)	9.1 (3.8)	1.8 (3.3)	10.25 (5.1)	1.18 (3.9)	3.0 (4.2)†
CERAD Verbal Fluency (Animals; n = 12)	9.7 (4.9)	9.66 (5.7)	-0.04 (2.8)	9.0 (6.3)	-0.67 (2.8)	-0.7 (3.1)
CERAD Boston Naming (15 Item; n = 13)	13.0 (2.3)	12.2 (3.2)	-0.85 (1.9)	11.8 (2.9)	-0.3 (1.8)	-1.15 (1.5)*
ABCD (n = 13)	17.63 (2.8)	17.14 (2.9)	0.49 (1.25)	15.86 (3.68)	-1.28 (1.56)*	1.77 (2.2)*
WAIS-R Comprehension percentile scores (n = 12)	64.6 (24.2)	58.75 (33.6)	-5.8 (22.7)	38 (25.5)	-20.75 (20.8)*	-26.6 (16.3)*
WAIS-R Similarities percentile scores (n = 12)	58 (37.3)	56.1 (33.7)	-1.9 (25.6)	49.8 (30.7)	-6.3 (18.8)	-8.2 (21.0)

MMSE = Mini-Mental Status Examination; CDR = Clinical Dementia Rating; CERAD = Consortium for the Establishment of a Registry for Alzheimer's Disease; ABCD = Arizona Battery for Communication Disorders of Dementia; WAIS-R = Wechsler Adult Intelligence Test-Revised.

\* $P < .01$ .

† $P < .05$ .

Fluency, Boston Naming, and WAIS-R Similarities between end of year 1 and end of year 2 testing. See Table 4.

The 3-year completers (n = 8) showed no decline on 6 measures: the CDR, Sum of Boxes, Boston Naming, ABCD, WAIS-R Similarities, and WAIS-R Comprehension between end of year 2 and end of year 3 testing. See Table 5.

The 4-year completers (n = 4) showed a significant improvement on Sum of Boxes between end of year 3 and end of year 4 testing and no decline on 5 measures: MMSE, CDR, Verbal Fluency, Boston Naming, and WAIS-R Comprehension. It is noteworthy that the 4-year completers showed no significant mean decline from baseline to end of year 4 on 6 measures: CDR, Sum of Boxes, Verbal Fluency, Boston Naming, WAIS-R Comprehension, and WAIS-R Similarities. Although there was a steep dip in performance on Similarities (abstract reasoning) in year 3, the group recovered to baseline level at the fourth-year testing session (see Table 6).

### Global Functioning

The multiyear completer groups showed no significant between-year changes on the CDR (stage of dementia).

All 4 of the 4-year completers were at the same CDR stage of dementia at the end of treatment as they were 4 years previously, 3 at CDR 1 (mild), and 1 at CDR 2 (moderate). One 3-year completer went from a baseline CDR of 0.5 (questionable dementia) to a 1; another who completed 6 semesters remained a 2 for the 3 years—this despite a hospitalization for a broken hip (not project related) in her fifth semester; she was 90 years old when the program ended. Of the other two 3-year completers, 1 started and remained a CDR 1 but had to drop out because of physical illness after her third year. The other started as a CDR 2, with an MMSE of only 15 and was rated a CDR 3 (severe stage) at the end of year 1 yet completed 2 more years of participation. She was finally terminated from our standard treatment because of her severe aphasia and incontinence. However, she continued to receive individual therapeutic services at her residence from a student volunteer and enthusiastically attended all of the program's social activities during its fourth year.

### Physical Fitness Gains

Significant gains on all measures were achieved: 6-minute walk, duration of aerobic exercise per session, and upper and lower body strength. For details, see the previous article in this journal.<sup>28</sup>

**Table 5. AD Rehab Outcomes: 3-Year Completers**

Test	Baseline Mean Scores (SD)	Year 1 Mean Scores (SD)	Mean Difference Scores		Year 2 Mean Scores (SD)	Mean Difference Scores		Year 3 Mean Scores (SD)	Mean Difference Scores	
			Baseline-Year 1 (SD)	Year 1-Year 2 (SD)		Year 2-Year 3 (SD)	Year 1-Year 2 (SD)		Year 2-Year 3 (SD)	Baseline-Year 3 (SD)
MMSE (n = 8)	23.0 (5.0)	20.4 (6.0)	-2.6 (2.7)*	-1.0 (1.9)	19.4 (6.2)	17.1 (6.4)	-2.25 (2.1)†	-5.9 (3.3)†		
CDR (n = 8)	1.28 (0.6)	1.4 (0.8)	0.16 (0.35)	0 (0.7)	1.56 (1.1)	1.75 (0.7)	0.2 (0.4)	0.47 (0.5)*		
Sum of Boxes (n = 8)	7.4 (3.1)	8.25 (4.0)	0.84 (2.3)	-0.2 (4.1)	9 (6.2)‡	10.6 (3.6)‡	2.6 (3.1)	3.2 (1.7)		
CERAD Verbal Fluency (Animals; n = 8)	10.2 (5.6)	10.6 (5.9)	0.44 (3.0)	0.125 (1.9)	10.75 (6.4)	9.25 (6.3)	-1.5 (0.53)†	-0.9 (2.3)		
CERAD Boston Naming (15 Item; n = 8)	12.75 (2.8)	12.1 (3.6)	-0.6 (1.7)	-0.375 (1.2)	11.75 (3.5)	11.6 (3.7)	-0.125 (1.7)	-1.1 (1.2)*		
ABCD (n = 8)	18.11 (2.8)	17.87(2.95)	-0.24 (0.83)	-0.6 (0.82)*	17.27 (2.8)	16.77 (3.7)	-0.51 (1.44)	-1.35 (0.59)*		
WAIS-R Comprehension percentile scores (n = 8)	65.25 (25.8)	61 (32.4)	-4.25 (25.2)	-19.4 (24.4)*	41.6 (24.2)	41.2 (28)	-0.45 (21.4)	-24.1 (17.9)†		
WAIS-R Similarities percentile scores (n = 8)	54 (40.3)	56.25 (32.7)	-2.25 (29.3)	-5.6 (23.2)	50.6 (29.9)	40 (34.5)	-10.6 (19.2)	-14 (23)		

MMSE = Mini-Mental Status Examination; CDR = Clinical Dementia Rating; CERAD = Consortium for the Establishment of a Registry for Alzheimer's Disease; ABCD = Arizona Battery for Communication Disorders of Dementia; WAIS-R = Wechsler Adult Intelligence Test-Revised.

\* $P < .05$ .

† $P < .01$ .

‡ $n = 5$ .



Table 6. AD Rehab Outcomes: 4-Year Completers

Test	Baseline		Year 1		Year 2		Year 3		Year 4		Mean Difference							
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Year 1-Year 2	Year 2-Year 3	Year 3-Year 4	Baseline-Year 4				
MMSE (n = 4)	23.75	(5.1)	23.25	(5.1)	21.75	(5.6)	20.0	(5.7)	19.75	(4.1)	-1.5	(1.3)	-1.75	(1.7)	-0.25	(1.7)	-4.0	(1.6)*
CDR (n = 4)	1.19	(0.55)	1.25	(0.5)	1.33	(1.15) <sup>†</sup>	1.75	(0.5)	1.25	(0.5)	0	(1.0)	0.33	(0.58)	-0.5	(0.58)	0.06	(0.125)
Sum of Boxes (n = 4)	7.4	(2.2)	7.1	(3.3)	7.0	(6.1) <sup>†</sup>	10.25	(2.1) <sup>†</sup>	8.0	(1.8)	-0.67	(5.5)	3.33	(4.2)	-2.25	(0.96)*	0.56	(0.515)
CERAD Verbal	11.1	(6.5)	13.0	(6.3)	13.0	(6.3)	11.5	(6.4)	10.75	(2.9)	0.0	(2.3)	-1.5	(0.58)*	-0.75	(3.6)	-0.375	(3.8)
Fluency (Animals; n = 4)																		
CERAD Boston	14.0	(1.4)	13.5	(1.7)	13.0	(1.4)	13.0	(2.4)	13	(2.3)	-0.5	(1.3)	0.0	(2.4)	0.0	(0.82)	-1.0	(1.4)
Naming (15 Item; n = 4)																		
ABCD (n = 4)	19.28	(1.92)	19.2	(2.07)	18.55	(2.1)	19.06	(2.15)	16.56	(2.4)	-0.7	(0.35)	0.51	(0.19)	-2.5	(1.9) <sup>‡</sup>	-2.7	(1.8) <sup>‡</sup>
WAIS-R	68.3	(25.4)	81.0	(14.8)	54.3	(26.1)	41.8	(29.1)	53	(25.9)	-26.8	(24.5)	-12.5	(17.7)	11.25	(13.1)	-15.3	(21)
Comprehension percentile scores (n = 4)																		
WAIS-R Similarities percentile scores (n = 4)	55.8	(47.8)	71.0	(34.8)	61.3	(32.3)	37.5	(30.2)	65.5	(26.1)	-9.8	(9.6)	-23.8	(10.7) <sup>‡</sup>	28.0	(21) <sup>‡</sup>	9.8	(22.2)

MMSE = Mini-Mental Status Examination; CDR = Clinical Dementia Rating; CERAD = Consortium for the Establishment of a Registry for Alzheimer's Disease; ABCD = Arizona Battery for Communication Disorders of Dementia; WAIS-R = Wechsler Adult Intelligence Test-Revised.

\* $P < .01$ .

<sup>†</sup> $n = 3$ .

<sup>‡</sup> $P < .05$ .

## Discourse Outcomes

Of the 4 subjects who completed 4 years of treatment, 2 maintained or improved performance on 5 of the 6 discourse measures; the other 2 maintained or improved on 3 or 4 of the measures. Maintenance of function or improvement on several of the discourse measures was also achieved by the program's 11 first-year participants. The analysis method developed and used, as well as complete first year and final year outcome data, have been described elsewhere.<sup>25,26</sup>

## Student Learning Gains

Six cohorts of students ( $n = 69$ ) were given an updated version of the AD Knowledge Test<sup>40</sup> before and after their participation. The mean score improved from 54% correct answers to 84%; change was very significant ( $P < .001$ ). Highly positive course evaluations, personal letters of thanks to the project director, the prominence of this experience as described in students' graduate school and job applications and reflected in future career plans, and postprogram involvement of students with their former partners are further evidence of the positive impact of the program on student participants. Follow-up phone calls and e-mails to former student participants in the spring of 2004 revealed that 11 of the 15 contacted were in or had completed medical, nursing, physical therapy, or speech pathology graduate programs.

## Caregiver Reactions

Sixteen caregivers responded to an evaluation questionnaire after the program's first year. The most frequently endorsed program benefit was opportunities to socialize (14 respondents). Other frequently endorsed benefit items were improvement in mood/morale, feelings of usefulness, energy level, and general quality of life (10 respondents each); connectedness to others (9 respondents); and conversation quality (8 respondents). Of the 4 program components, exercise was ranked the highest, in terms of perceived benefit to participants, followed by volunteer work, conversation stimulation, and memory training.

## AD Rehab Outcomes Compared to CERAD Outcomes

The CERAD study tracked cognitive change in untreated AD patients from 1986 to 1994.<sup>41</sup> Data from

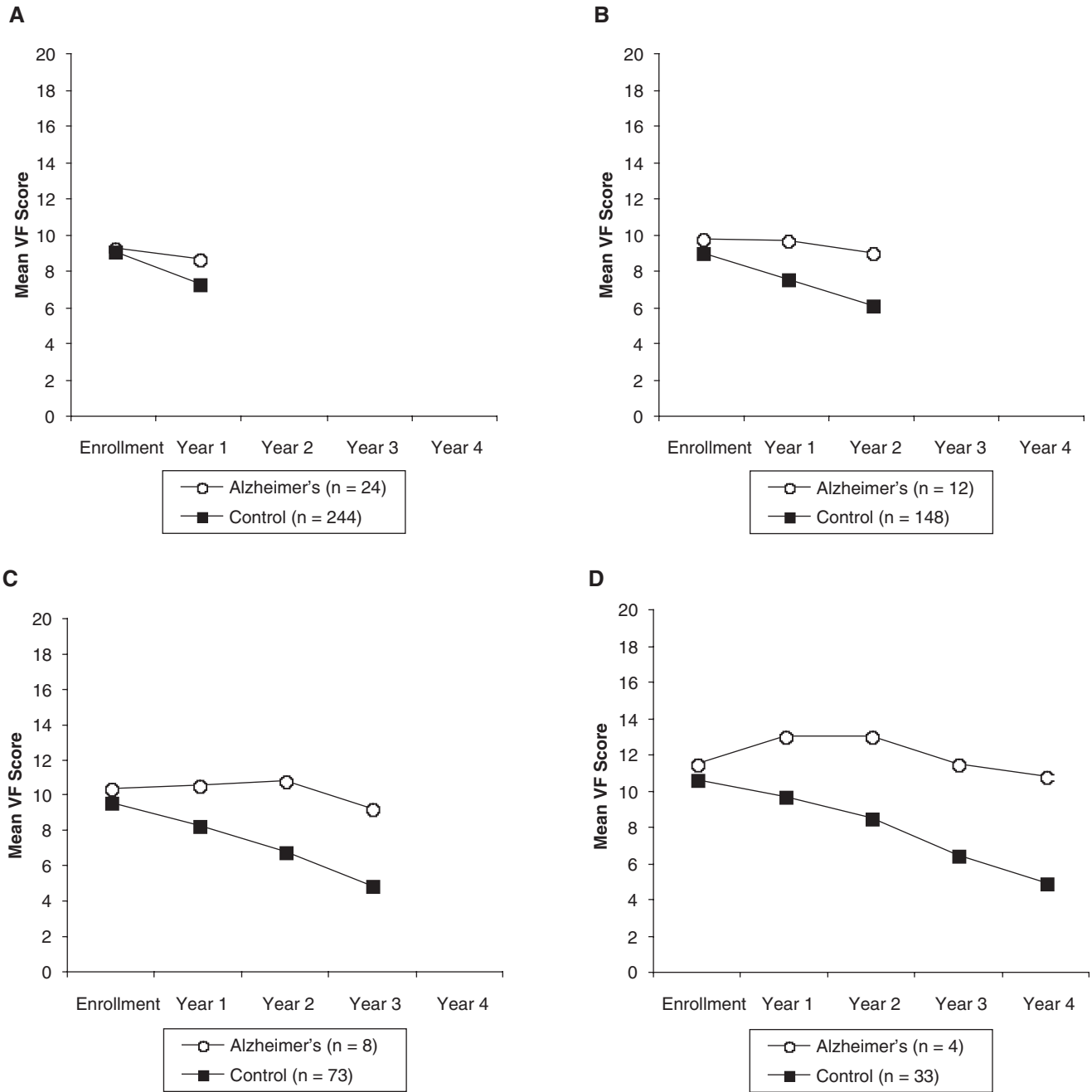
the 245 individuals in the CERAD database who most closely matched the 24-person Elder Rehab sample on diagnosis, age (54 to 59 years and 73 to 88 years), race (white), and MMSE score at enrollment (15-29) were used as a comparison group. These 2 groups were compared at enrollment, and those remaining in the CERAD sample at first-, second-, third-, and fourth-year follow-up testing were compared with the AD Rehab cohorts on the following measures: MMSE, CDR, Sum of Boxes, Boston Naming, and Verbal Fluency.

Data were analyzed using a (Groups  $\times$  Time) mixed ANOVA. Results of post hoc comparison of test scores on the MMSE, CDR, Verbal Fluency, and CERAD 15-Item Boston Naming showed no difference between groups during the first year, and both groups declined significantly ( $P < .001$ ). However, analyses of data from subsequent years of the projects suggest that the groups began to diverge after the first year. For example, the CERAD group declined an average of 4 points on the MMSE from year 1 to year 2 ( $P < .001$ ), while the AD Rehab group declined just 2 points during the same time period ( $P = .02$ ). From year 2 to year 3, the CERAD group declined by 3 points ( $P < .001$ ), and the AD Rehab group declined by 2 points ( $P = .02$ ). The difference was most striking between year 3 and year 4, when the CERAD group declined by 3 points ( $P < .001$ ) and the AD Rehab group by just 1 point ( $P > .05$ ).

In the AD Rehab group ( $n = 24$ ), 50% of the group had an average annual rate of decline during their participation in the project of less than 3 points. In the CERAD group ( $n = 245$ ), only 42% of the group had an average rate of decline of less than 3 points. A binomial test comparing the 2 proportions indicated that the 8% difference was statistically significant ( $P = .02$ ). Results of analysis of the Verbal Fluency, Boston Naming, CDR, and Sum of Boxes tests mirrored that of the MMSE. See Figures 1a to 1d, which compare the performance between the 2 groups on the Verbal Fluency test.

## Discussion

Because the present study sample was so small and there was no randomly assigned local control group, it is premature to claim that these interventions will slow cognitive decline in the general population of AD sufferers. The superior performance of the multiyear AD Rehab participants relative to the untreated CERAD matched sample may have been a



**Figure 1.** Comparison of elder rehab and Consortium for the Establishment of a Registry for Alzheimer's Disease participants on Verbal Fluency (VF) test at years 1, 2, 3, and 4.

chance occurrence, although the consistency of the performance differences across all 5 of the variables on which they were compared weakens that hypothesis. Did the AD Rehab interventions cause the across-the-board maintenance of function among the 4 persons who successfully completed all 4 years? That is a tough question to answer. As

reported previously, the 4 participants were compared to the other AD Rehab participants on 6 baseline variables and were no different (see Table 7).

There was probably some unmeasured element of robustness that characterized these 4 individuals that, combined with the stimulation of the program, accounted for their success.

**Table 7.** Mean Baseline Characteristics of Alzheimer's Disease Rehab 4-Year Completers Compared to Other Participants

Group	Age	Education	MMSE	ABCD	CDR	No. of Comorbidities
4-Year completers (n = 4)	80.3 (4.3)	12.5 (10.9)	23.75 (5.1)	19.275 (1.9)	1.19 (0.55)	2 (0.82)
Other participants (n = 19)	78 (12.7)	13.1 (2.5)	23.3 (3.9)	17.75* (2.31)	1.18 (0.61) <sup>†</sup>	2 (1.25)
<i>t</i> score	0.67	0.47	-0.19	-1.2	-0.026	0.00
<i>P</i> value	$P < t = .75$	$P < t = .68$	$P < t = .42$	$P < t = .12$	$P < t = .49$	$P < t = .50$

MMSE = Mini-Mental Status Examination; ABCD = Arizona Battery for Communication Disorders of Dementia; CDR = Clinical Dementia Rating.

\*n = 18.

<sup>†</sup>n = 12.

Because there were multiple interventions, it is not possible to determine which of them—singly or in combination—accounted for the positive outcomes achieved. Further research is needed to dissociate the various treatment elements (physical exercise, cognitive exercise, and supervised community volunteer work) and compare their effects on randomly assigned groups of demographically and clinically equivalent participants. The assumption that combining exercise with language-stimulation activities has a booster effect on language performance needs to be tested by comparing the effects of language stimulation alone versus exercise plus language stimulation. Similarly, the effects on language and cognition of supervised involvement in volunteer service and varied community activities versus exercise might be compared.

Such studies would yield information that could inform treatment planning for persons who already have dementia and other diseases of aging.

## Clinical Implications

Clinically, there is much to be said for leaving the combined intervention intact. By offering a variety of activities, you are providing multiple and different opportunities for participants to be successful. Someone whose language skills are seriously compromised and resist improvement can still achieve pleasure and satisfaction from rocking babies at a day care center and/or make tangible and esteem-building gains in speed or duration of aerobic activity or increases in amounts of weight lifted. A frail individual who cannot do well on the physical activities may benefit from the cognitive activities and be able to

read stories to preschoolers or newspapers to a blind person.

A meta-analysis of exercise studies involving mostly nursing home residents found that those that combined exercise with another intervention, such as music and language activities, had a greater effect size.<sup>42</sup> The benefits of doing volunteer work were previously cited. A Swedish study of 1200 persons aged 75 years or older found that the more socially isolated elderly people were, the more likely they were to develop dementia.<sup>43</sup> While there is no evidence that involving persons who already have dementia in social situations will slow or halt their decline, the social and quality-of-life benefit of regular participation in mentally and physically stimulating and community-serving activities with a student is self-evident. Mood and physical fitness benefits are virtually ensured. Slowing of cognitive decline is less predictable and difficult to measure but a bonus if it occurs. As fitness and mood improvements are the most ensured benefits, the interventions have applicability to persons suffering from depression as well as elderly persons without disabilities. They would be particularly beneficial for African Americans, Hispanics, and Native Americans who suffer disproportionately from diabetes and cardiovascular diseases, conditions that can be ameliorated by exercise.<sup>44-46</sup>

The steadily increasing size of the dementia-affected and dementia-vulnerable population coupled with the rising cost of health care make the need for affordable life-enhancing treatments greater than ever before. Existing medications are expensive, have side effects, and help only some patients—and these only modestly and temporarily. They do nothing to alter the relentless and dispiriting shrinking of opportunities for socialization and

meaningful activity that is the lot of persons with a progressive dementia.

College students are a readily available and constantly replenishing resource in most communities. Whether working for academic credit, to fulfill volunteer service requirements of their financial aid packages, or for pay, students can be the ticket to improved physical and mental fitness and quality of life for AD patients and a source of respite and social support for caregivers.

## Appendix A Discourse Stimulus Prompts

1. Tell me what you know about John F. Kennedy and his family. (Also used to assess memory.)
  2. Tell me what you know about Alzheimer's disease. (Also used to assess insight.)<sup>47</sup>
  3. Tell me about your daily activities, the things you do every day.
  4. Tell me about the things you do once in a while, not every day. (Three and 4 also assessed level of awareness about current life.)
  5. Tell me the childhood thoughts and memories the word *play* reminds you of.
  6. Tell me the adult thoughts and memories the word *play* reminds you of.
  7. How would you go about planning a picnic for your family or some friends? (Also assesses procedural memory.)
  8. Suppose the 13-year-old daughter of a neighbor told you she was pregnant but was afraid to tell her mother. What would you do? What are some ways the family could handle that situation? (Also assessed problem-solving ability.)
- Five-item proverb interpretation task.
1. They see eye to eye.
  2. Too many cooks spoil the broth.
  3. Rome wasn't built in a day.
  4. Don't count your chickens before they hatch.
  5. You can't tell a book by its cover.

The picture description task involved describing the grocery store picture from the *Aphasia Diagnostic Profiles* by Helm-Estabrooks.<sup>48</sup>

## Appendix B AD Rehab Language Activities: Examples of Each

1. **Category Fluency.** (While on treadmill or bike.) Name as many \_\_\_\_\_ [fruits, modes of transportation, types of clothing, etc] as you can in 60 seconds. Alternative: Tell subject you will name a category and count to 10, during which time he or she is to name something from that category. Use a series of categories. Have subject give categories for you to name from.

2. **Picture description.** (During rest period.) Present Norman Rockwell or other evocative picture. Say, "Tell me what you see in that picture—what's going on." Record free response. Then ask prompt questions. **Example:** Homecoming (picture of soldier coming home and being greeted by family and neighbors).

Prompt questions used after free response is recorded:

What is the occupation of the young man in the picture with his back to us? How can you tell? [Uniform] Who are the people on the back porch? What kind of emotions are the people in the picture feeling? How can you tell? Do you think he's home for a short visit or for good? [Small bag—probably short visit] What kind of neighborhood does this soldier live in? How can you tell? Who do you suppose the young woman is who is leaning against the side of the house? How do you think she is feeling? What do the mother and all of her children in the picture have in common? [Red hair] About how old would you guess that mother is? What could be causing her legs to be so fat? [Fluid retention from heart problems] Do women of that age look like that nowadays? How does being well-to-do financially help a woman look younger than poor women of the same age? Did you ever have a loved one in the service? Who? What was that like? If you were in the service, what were short visits home like? How did you and your family keep in touch? Have you saved any letters from those years? What famous entertainer used to give shows at overseas military bases at Christmas time? [Bob Hope]

3. **Word Associations.** (While on treadmill or bike.) Tell me all the [childhood, adult] thoughts and memories the word reminds you of [eg, *birthday, garden, graduation, funeral, thunderstorm*]. (Student shares stories from his or her life on same topic.)

4. **Opinion and Advice Questions.** (During rest period.) A situation involving a moral issue or personal values is presented to the subject, and his or her opinion is solicited. A series of probing questions is asked after free response is recorded. **Example:**

### Affair

Suppose you found out that your best friend's husband was having an affair and spending a lot of money on an attractive widow living in your community. Your friend and her husband are living on a limited retirement income, half of it from the wife's pension. You're afraid for her financial well-being but don't want to hurt her.

*What would you do?*

Prompt questions after free response is recorded:

Would you say anything to the cheating husband? What? Would you say anything to your friend? What? What would you advise her to do? Do you think trust can be rebuilt in a marriage after one partner has been unfaithful? How? If it were your husband (or wife) having



an affair, would you want to be told about it? Would you feel appreciative or resentful toward the friend who told you about the affair?

5. **Story Recall.** (During rest period.) Student reads brief story containing 6 to 7 facts and asks subject to repeat story. Student then rereads story, posing a question about each fact after it is stated, pausing for the subject to answer, if able, then gives the correct answer. Student then repeats the 6 questions that were embedded in the story and records answers, giving correct answer, if necessary. Subject is then asked to tell the story again. When all 6 questions are answered correctly and subject recalls 4 major facts about the story, a new story is introduced for the following session. **Example:**

#### Poor Puppy

A cocker spaniel puppy that is usually kept in the basement got into the living room when the owner was at work. When the puppy's owner got home, she found a wet spot on the carpet. She spanked the puppy with a newspaper. Then she noticed water dripping from the ceiling right over the wet spot on the carpet. She apologized to the puppy and gave him a biscuit.

This story is about a cocker spaniel puppy. What kind of puppy is the story about? [Cocker spaniel] The cocker spaniel puppy is usually kept in the basement. Where is the puppy usually kept? [In the basement] One day, the puppy got into the living room when the owner was at work. Where did the puppy go while the owner was at work? [Into the living room] When the puppy's owner got home, she found a wet spot on the carpet. What did the puppy's owner find on the carpet when she got home? [A wet spot] She spanked the puppy with a newspaper. What did the owner do to the puppy? [Spanked him with a newspaper] Then she noticed water dripping from the ceiling right over the wet spot on the carpet. What really caused the wet spot on the carpet that the puppy was blamed for? [Water dripping from the ceiling]

6. **Proverb Completion.** (While on treadmill or bike.) Give the beginning line of a proverb; ask the subject to give the ending. **Example:**

You can lead a horse to water \_\_\_\_\_ [but you can't make him drink].

**Proverb Interpretation.** (During rest period.)

Read the proverb beginning to see if they know the ending. Write down what they say. Ask them the meaning of it, and write down what they say. If the subject gives a concrete or incorrect response, then read the abstract interpretation. Then read the proverb again and ask the subject to interpret it. Write it on record sheet. **Example:**

A bird in the hand \_\_\_\_\_ [is worth 2 in the bush].

(The things we already have are more valuable than the things we only hope to get. Better to hang on to what you

have than to take a chance on something you might not be able to get.) Good source of proverbs: *Dictionary of Cultural Literacy* by Hirsch, Kett, and Trefil.<sup>49</sup>

7. **A My Name Is Game.** (During rest period or while on treadmill or bike.) Subject is told that this exercise is to practice producing words quickly. Have subject read or say the framework phrase with the student and produce a word beginning with the target letter for each blank. **Example:**

A my name is \_\_\_\_\_ and my [husband's/wife's] name is \_\_\_\_\_ and we come from \_\_\_\_\_ and we're going downtown to buy \_\_\_\_\_. B my name is \_\_\_\_\_, etc.

8. **Similarities.** (While on treadmill or bike.) Subjects are asked what the 2 words in each pair of items have in common—how they are alike. **Examples:**

Cup and plate \_\_\_\_\_  
Shark and tuna \_\_\_\_\_  
Vodka and gin \_\_\_\_\_

9. **Famous Names.** (While on treadmill or bike.) Subjects are read a series of first names and are asked to name a famous person with that first name. Students then ask if the subject can tell something about that person, and students share what they know. **Examples:**

George [Washington/Gershwin/Burns] (president, composer, actor/comedian)  
Jimmy [Carter/Hoffa/Durante] (president, union leader, comedian/actor)

10. **Pros and Cons.** (While on treadmill or bike.) Subjects are read a series of topics or objects. For each one, they are asked to tell what's good about it and, then, what's bad about it. The student uses topic and responses as a launch pad for a conversation, sharing his or her opinions during the dialogue. **Examples:**

Television  
Being retired  
Cell phones

11. **Sentence Completions.** (While on treadmill or bike.) Subjects are given a series of sentence stems and are asked to complete them. Students offer responses also and engage subject in dialogue about the topic. **Examples:**

If I had a million dollars, I \_\_\_\_\_.  
I'm afraid of \_\_\_\_\_.  
My favorite dessert is \_\_\_\_\_.

12. **Picture Naming and Quiz.** (During rest period.) Pictures, alternating with questions about items in a category of objects (study task), were presented over a period of weeks following a period of weeks when the subject was repeatedly asked to name objects from that category during 60-second category fluency tests. An hour after the study task, the category fluency test is given. Exposure to the quiz typically results in the subject's naming objects that appeared on the quiz as well as novel

objects from the target category, that is, not named during the previous fluency tests and not on the study task. A good way to maintain and increase lexical fluency.

**Example:** (Category: modes of transportation)

1. Picture of a hot air balloon is shown and subject is asked, "What is this?"
2. What do you call the moving staircase that is found in department stores? [Escalator]

**13. Object Description.** (During rest period.) A common object is presented, and the subject is asked to describe it. After the subject finishes free response, cue questions are asked to elicit information not spontaneously given:

What is its shape? What color is it? What is it used for? Where can you get it?

**Examples:** Lemon, pencil, toothbrush.

**14. Traveling Bingo.** (While riding to and from activity site.) A card is created that contains 12 or 16 squares, each containing the name of something one might see from a car window (eg, red pickup truck, school bus, police car, driver with a beard, passenger with a ponytail, pizza delivery truck). Depending on the capability of the subject, the whole card is played or 1 or more objects are targeted for a particular trip. (Great for long car trips with children!) Involve subjects (or kids) in suggesting items to put in the squares.

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