Transfer of a Speed of Processing Intervention to Near and Far Cognitive Functions

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Key Words
Processing, speed - intervention - cognitive training

Abstract
Background: Evidence establishing the potential for modification of cognitive functioning in later adulthood has begun to accumulate. Objective: The primary goal of the current study was to evaluate, among older adults, the extent to which standardized speed of processing training transfers to similar and dissimilar speeded cognitive measures as well as to other domains of cognitive functioning. Methods: Ninety-seven older adults (mean age 73.71 years) were administered a battery of cognitive tasks assessing intelligence, memory, attention, verbal fluency, visual perceptual ability, speed of processing, and functional abilities. Forty-four of the 97 participants received ten 1-hour sessions of speed of processing training. The remainder of participants were in a no-contact control group. Approximately 6 weeks after the pre-training assessment, all participants repeated the same battery of tests. Results: The results revealed training effects for some speed of processing measures, including performance of instrumental activities of daily living, but no transfer to other domains of cognitive functioning. Conclusion: Speed of processing training may enhance the speed at which older adults can perform instrumental activities of daily living.

Introduction
There is a long history of research in cognitive aging that indicates as people grow older, they experience declines in multiple domains of functioning [1]. Cognitive abilities such as speed of information processing, memory, and reasoning ability may be affected, resulting in declines in the ability to perform everyday tasks such as managing money, taking medications, and driving [2-5]. These changes raise a number of questions. First, is there concern that the percentage of older adults in the general population continues to increase over the next 25-36 years, there will be a growing number of older adults who cannot function independently, thereby placing an emotional and financial strain on the older adults themselves, their caregivers, and society. Second, there is considerable research interest in examining the nature of age-related declines in multiple areas of functioning in order to develop more effective interventions to prevent, slow, or reverse such effects. Cognitive training studies can be useful in answering questions about potential methods of slowing, preventing, or reversing age-related cognitive decline. Evidence establishing the potential for modification of cognitive functioning in later adulthood has begun to accumulate [6, 7]. This foundation of research provides empirical support for the potential of cognitive interventions to enhance everyday cognition and functional abilities.

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Training protocols have been developed for the improvement of memory, reasoning, and speed of processing, among other abilities [6, 5-16]. Several training studies have been conducted using the protocol from the Adult Development and Enrichment Project (ADEPT) [5, 6, 11, 17, 18]. The ADEPT training protocol consists of five 60- to 90-min sessions. Two types of training can be administered: figure rotation training, which involves making strategies to facilitate mental rotation of figures, or reasoning training, which involves teaching different rules or strategies to solve letter series, letter sets, and number series problems. Training studies using the ADEPT protocol have generally found that training results in improvement on several near-speed and near-transfer tasks of the trained ability [7]. However, training effects do not appear to transfer to measures of abilities that were not the focus of training [18]. Specifically, participants who received reasoning training demonstrated significant improvement in tests of reasoning ability, but did not demonstrate improvement on tests of spatial ability. Likewise, participants who received spatial training demonstrated improvement on spatial tests, but not on tests of reasoning ability.

Studies on memory training have involved a variety of training protocols and often have used a multifactorial approach [12, 14, 15]. For example, Oswald et al. [16] compared the effectiveness of five different treatment approaches: comprehension training, memory training, psychomotor training, combined computation and psychomotor training, and combined memory and psychomotor training. The results indicated that a combined approach of memory and psychomotor training resulted in a reduction of dementia symptoms for up to 2 years following training. Niedt and Bickman [15] conducted a memory training study in which they found transfer of training for recall of concrete words - the task most similar to the training itself. Transfer was also found for another memory task of object recall; however, no transfer was found for subject-performed and abstract words recall tasks.

The present study examines the extent of transfer of speed of processing training. Our protocol for speed of processing training was designed based on the Useful Field of View (UFOV) concept developed and described by Bal and Osley [8] and Hall et al. [9, 15]. The UFOV test provides a measure of the visual area from which one can extract information in a single glance without eye or head movement. The UFOV test in a processing speed measure that is expedient for evaluating age-related slowing under a variety of task demands. Several studies have found that older adults performing poorly on the UFOV test are at greater risk of automobile crashes [3, 20-22]. Furthermore, adults with a reduction in UFOV are more likely to fail an on-the-road driving test [23]. Given such findings, a larger expansion of the research is to examine whether speed of processing training results in improved driving performance. Such research has indicated that individuals who received this training demonstrated significantly faster processing on the UFOV test (the nearest transfer measure), showed improved stopping time to read signs while in a driving simulator (a near-transfer measure), and made fewer dangerous maneuvers on an on-road driving test (the functional outcome of interest) [8]. The control group received an equivalent amount of training in a standard drive improvement class, but did not demonstrate these gains. These findings indicated that speed of processing training transfers to nearmeasures of processing speed as well as to the functional outcome of training quickly to hazardous situations while driving [8].

The primary goal of the current study was to evaluate the benefits of transfer of speed of processing training to multiple cognitive measures along a conceptually broad continuum of near to no transfer (see Table 1). A critique of previous training studies has been that only fast-transfer tasks have been examined. Therefore, we choose to involve a large range of measures, including both some measures that were closely related to the training and some that were not - a methodology employed by Willis et al. [7]. Various measures commonly used in cognitive aging research across a wide variety of domains such as speed of processing memory, executive function, visual spatial skills, and crystallized intelligence were included in the protocol.

The UFOV was categorized as the nearest transfer measure because the training protocol is most similar to this assessment task. Furthermore, previous research has found transfer of training to this task [8]. All other measures of speed of processing were categorized as near-transfer along the continuum, since processing speed is the construct targeted by training. It was hypothesized that training would most impact UFOV, Road Sign Test, and Timed IADL (instrumental activities of daily living) Test performance, since these rely heavily upon rapid information processing and visual search. The Road Sign Test is similar to the intervention in that it is a speeded task that involves visual search for a target surrounded by distractors. Furthermore, prior research has found transfer of speed of processing training to this measure as pr...
formed in a driving simulator [8]. The components of the Timed IADL Test also involve visual search in the midst of distracting information, and prior research has indicated that performance on the test is moderately associated with UPDRS performance \( r = 0.54 \)[24]. It was further hypothesized that transfer of training would also be evident in the more traditional pencil-paper measures of speed of processing [1] (e.g., Letter and Pattern Comparison, Digit Symbol, Finding A’s, Identical Pictures).

Measures of executive function and memory were also included in the protocol in order to evaluate breadth of transfer. These measures were categorized as far transfer, because although prior research has indicated that performance on such tasks is associated with speed of processing [25–29], these measures are not considered to be pure markers of the speed construct itself. Furthermore, these measures are not familiar to the intervention, and prior research has not found transfer of training to dissimilar tasks [30]. Thus, it was hypothesized that the training would not significantly impact performance on executive function or memory tasks.

Finally, we hypothesized that training would not transfer to performance on visual spatial or crystallized intelligence measures. These were considered to be no-transfer tasks in that they have not typically been highly associated with speed of processing, and most of the tasks included in the battery—e.g., Wechsler Adult Intelligence Scale (WAIS) Information and Facial Recognition—did not involve a speed component. Although transfer was not expected, these measures were included in the battery in order to truly examine the extent of transfer across a wide variety of cognitive domains.

**Methods**

**Design**

The present study was a 2 × 2 mixed design with testing occasion as the within-subject variable and type of training as the between-subject variable. Prior to the start of training, all participants were assessed on a battery of tests of cognitive ability. Following the assessment, carrier participants were randomly assigned to either the training or the control group. Approximately 6 weeks after the pretraining assessment, the participants were again assessed on the cognitive battery. Ninety-one of the participants completed the protocol.

**Sample and Procedures**

Ninety-one community dwelling older adults (42 males and 55 females, 42 Caucasians, 31 African Americans, 2 others, 2 unclassified) participated in the study. The sample had an average age of 73.7 (range 61–93) years and an average education of 13.45 (range 6–20) years. The participants were recruited from prior studies and from a university program for older adults called Medavee. This program offers education and research opportunities to individuals 55 years and older. All participants reside in Jefferson County, Alabama, or the surrounding area.
Measures

Health Status
Participants were asked whether a doctor or nurse had ever told them that they had any of the following conditions: allergies, heart disease, diabetes, high blood pressure, convulsions, mental retardation, arthritis, multiple sclerosis, depression, cancer, stroke, Parkinson's disease, or dizzy spells.

Cognition
Training speed of processing tasks was selected to improve the participants' speed-related mental fatigue, but not to generalize to cognitive domains such as crystallized intelligence. In order to determine the presence or absence of training-related improvements in various cognitive abilities, we selected a diverse cognitive battery. Measures were selected for this battery based upon strong evidence indicating that the component tests are relatively pure markers of the cognitive domains of interest. Measures of processing, executive function, visual-spatial skills, memory, and crystallized intelligence. Even so, we acknowledge that the battery represents a relatively unmeasured aspect of simple domain, and virtually all tests tap more than one domain. Thus, in choosing tests for the battery, consideration also was given to the ecological validity of each test, the amount of time and expertise required for test administration, and the availability of appropriate normative data for each test. We selected more than one measure of each putative cognitive domain in order to more fully represent each construct of interest. Based upon empirically based conceptualization of speed of processing and its relationship to other cognitive functions, we constructed a composite of cognitive domains, with constitute measures of each ranging from the closest relationship (nearest) to a more relationship. These paired relationships allowed the correlation of the relationship of the test battery. This would allow us to compare the extent to which measures depend on processing speed (e.g., Useful Field of View, Letter and Patterns Comparison) to measures independent of processing speed domains (e.g., WAIS-R revised Information (see Table 1). As noted, the primary outcome variables were represented by multiple predictors.

Speed of Processing
Useful Field of View. The UPFV [19] measures the speed at which one can rapidly process multiple stimuli in the visual field. This means is ecologically valid in that it has been shown to be an independent predictor of productivity outcomes and of other criteria in particular—among older adults. In three increasingly complex matrix, central, peripheral, and distractor stimuli are presented as white targets (2 x 1.5 cm) with an otherwise black background on a 12-in computer monitor. The participants view the stimulator from a distance of approximately 18 in. The three subtests require the examinee to identify and localize targets with presentation duration ranging between 17 and 300 ms. Each trial consists of four display frames (1) fixation box, (2) test stimuli, (3) a finished, white-screen, visual mask, and (4) a response screen. The display size visual mask is presented following the stimulus in order to control the process speed and to eliminate afterimages. In the first subtest, basic speed of processing, the examinee identifies a central target (car or truck) presented in a fixation box. In the second subtest, divided attention, the examinee identifies the central target and also localizes a simultaneously presented peripheral target (bus). The third subtest, selective attention, also demands simultaneous identification of the central target and localizing of the peripheral target. However, in this subtest, the peripheral target is embedded in distractors, making the task more difficult. Peripersonal measures are presented in millisecond at which examinee correctly perform each subtest. Scores for each of the three subtests were converted into a single composite score.

Road Signs Test. The Road Signs Test is a laboratory-based measure of everyday visual scan skills. The measure was being developed during the course of this study. The participants viewed new signs (municipal, bicycle, right- and left-turn arrow) with and without red slash through them on a computer screen. They were instructed to disregard signs with a red slash (dangerous) and respond as quickly as possible, using a computer mouse, to signs without a slash (safe). The participants were instructed to react to right and left-turn arrow moving in the mouse in the direction indicated by the arrow. They were told to support the biased polygons signs by clicking a mouse button. The average reaction time in seconds required for a correct response was on a trial. Median through the participant the Road Signs Test was similar to as presented form. Thus, two different versions of the test were included in the present study. In each version of the test, each condition involves the target wand the sign without a red slash and a number of distractor signs (signs with red slashes). The earlier version of the test included four different conditions (either 0, 3, 5, or 6 stimuli). This version was completed at both pre- and post-training sessions by each participant. For this version, six trials of each condition were completed for a total of 24 trials. The second version of the test also presents a total of 24 trials, but some trials are composed 12 trials each of the 0, 3, 5, and 6 stimuli conditions (the 4 and 6-stimuli conditions were dropped from the present study). This revised version of the test was completed in both pre- and post-training sessions by each participant. The average reaction time in the second version was similar to those who took the original version as well as those who took the modified version of each trial.

Timed Tasks. The Timed Tasks Test [24, 25] involves laboratory measurement of five timed tasks that resemble everyday instrumental activities of daily living finding a telephone number for a given picture in the telephone directory, finding and reading the ingredients on a food label, finding two food items in an array of food items, reading and understanding a medical insurance card, and reading a prescription. This task was selected as a measure of the participants' ability to read, write, and interpret information. The tasks were selected because they represent everyday activities that are important for independence. The participants were asked to complete each task as quickly and accurately as possible. Each participant was asked to complete the tasks in a specific order: the telephone directory task was the first task, followed by the food items task, then the insurance card task, and finally the prescription task.
tor, a psychomotor speed factor, is a memory-attention-concentra-
tion factor [35]. The participants are shown a sequence of ten im-
merous cards, one at a time for 5 sec, and are required to repro-
duce each design after it has been removed from sight. The scores reflect the number of designs correctly reproduced.

Reproduced Complex Figure Test (CFT: Copy and Immediate
Recall). The CFT [51] is a test of visual-spatial constructional ability
(copy) and visual memory (recall). More studies define a decline in performance on the CFT in normal adults with age which may be attrib-
uted to impaired storage of information [50]. The participants view the
eye-Detection complex figure [10] and are asked to copy the figure onto
another sheet of paper. Upon completion of this trial, the figure is
removed and the participants immediately reproduce as much of the
figure as possible from memory. The participants receive a score for
the copy trial and for the memory trial reflecting the number of figure
components that were correctly reproduced based on accuracy of
drawings and placements. Only the memory score was used in subsequent
analysis given that this aspect of the test was of more interest than
the constructional component.

Visual-Spatial Skills

WISC-R Block Design Subtest. This subtest [36] is a measure of
visual-spatial organization. Age has a significant impact on the per-
formance of this test primarily in that older adults often take longer
to complete the test primarily because of decreased speed and which
blocks to reproduce designs perceived on circular levels within a given
amount of time. Skewed scores are determined based on correct
drawings and placements within the allotted time.

Face Recognition Test (Short Form). The Facial Recognition
Test [53] examines the ability to recognize faces without a demand
on memory [31]. This test mainly taps visual-spatial processing and
abstract ability and is not dependent on processing speed. The par-
ticipants see a front-view photograph of a person and are required to
identify the same person in 3 of 6 photographs taken under either similar
or different angle or lighting conditions. The scores, which are based on the number of correctly identified matching
faces, are corrected for education level.

Crystallization Intelligence

WAIS-R Information Subtest. The information subtest [36] was
included as a test of discriminant validity for speed of processing
training effects (i.e., any gains in speed of processing should not affect
this crystallized ability). This unfiltered test places no demands in
processing speed and has been described as a test of general knowl-
dge that is less affected by aging and cognitive decline [10].

The participants answer a series of questions regarding general factual
information. Skewed scores are determined based on the number of
correct responses.

Training
For the first condition of the present battery, the participants were
randomly assigned to either no-contact control group (n = 47) or a
speed of processing training group (n = 44). Control participants
(CP; 39 Caucasian; 4 African-American; 2 other; 3 unreported) 27 females
and 20 males did not receive any training, but participated in both
pre- and post-treatment assessment sessions. This group had a mean age of
53.85 years and an average education level of 14.0 years. The two
training groups (25 Caucasian; 6 African-American; 26 females
and 18 males) were invited to attend ten group training ses-
sions of about 1 h each. These participants had an average age of
73.93 years and an average education level of 14.3 years. All ten
sessions involved 2–3 participants and began with a group discus-
sion of topics such as how attention skills made to everyday activi-
ties such as driving, avoiding falls and mobility. Most of the training
participants, all but 3, completed at least 8 out of the 10 training
sessions. The other 2 participants concluded less than five ses-
sions.

The three subtests that are used to evaluate UFOP are the model
for the speed of processing training. The participants do try to practice
the UFOP test itself, however, risks, for training purposes, the
complexity of the UFOP subtests is modified by reducing the du-
ration of the display and by gradually increasing the com-
plexity of the critical task, the peripheral task, or both. These modifi-
cations allow individuals to practice the tasks at customized levels of
certainty of difficulty and mastery is achieved. Thus, the serial training protocol requires the participant to practice a number of stimuli at a variety of stimulus durations. Some of these stimulus configurations may be ones that the individual experienced during UFOP assessment, but the majority of these are not.

Whereas the UFOP test involves varying display durations until an
individual's threshold is determined, the training protocol allows
display durations to be specified. Participants try to read the
display may be specified in seconds of the refresh cycle of the mon-
itor. For a 60-Hz monitor, a single refresh cycle takes approximately
16 ms. This allows individuals to focus on a given task or a constant
presentation speed, since that is mastered before progressing to
broader durations.

Each part of the UFOP screening test involves the critical
identification task. In training, however, the center line can be
repeated, requiring merely identifying the target, once can be made
more difficult, requiring a determination of whether two central
targets presented simultaneously are the same or different. Unlike the
UFOP test, in which all peripheral targets are presented at a distance of
2 or 4 sec from the central target, the training program allows the dis-
s estará of peripheral targets to be specified to either 2, 6, or 12 mm
from the central target. Moving the target farther toward the
periphery of the computer screen makes the task more difficult.
Training the software allows task complexity to be further modified
by changing the color of the peripheral target and/or the luminance
of the distractors. The goal of these training techniques is to
gradually increase the task difficulty at each session to the individu-
al. In order to present tasks that are challenging, but not too difficult, until
mastery of each task is achieved through practice.

Initial training sessions involved an introduction to and practice on
the three types of targets (single speed of processing, divided atten-
tion, and selective attention), with the three different central de-
rivations (education, classification, same/different). In subsequent
training sessions, tasks were customized to each participant's ability

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pay the protocol specified below. All sessions included groups of 2-2 participants and began with a group discussion.

A standardized speed-of-processing training protocol was used in this study. The protocol specifies that for participants with a threshold greater than 30 ms on UPV/1 target 1 individualized speed training begins with a repeated speed of processing task. Recall that although individual presentations may be no faster than 17 ms, the threshold represents the average duration at which the participant can perform the correctly 75% of the time. In this situation, participants provide a central task at progressively faster presentation speeds and at progressively more complex levels (selection, identification, name generation) of the task. Practice continues until the participant can perform the identification task correctly 75% of the time at an average duration of 25 ms or less. Once participants reach this criterion, training progresses to the divided attention task.

For participants with a threshold equal to or less than 23 ms on UPV/1 target 1, but greater than 30 ms on target 2, individualized training begins with the divided attention tasks. The divided attention tasks require the participant to perform a central discrimination task and also to locate a peripheral target (e.g., a square of a color that is preserved on 2 of the 8 radial directions from the center. Our prior experience and reflections (8) have shown that many of our tasks may be accomplished more expediently by using a drumming method. The basic idea behind this method is to select a display duration at which the individual has moderate ability to perform the task (i.e., the display duration closest to the baseline threshold average plus 3 ms) and then perform the peripheral target closer to the central target (i.e., ± 2 ms). The participant performs the task under three comparable conditions until mastery is demonstrated (175% correct performance for two consecutive blocks of practice). The peripheral targets are then moved toward the periphery (i.e., 6 ms), and the practice is repeated until mastery is achieved at the fastest criterion (11 ms). This protocol of progressing from near to far peripheral targets with increasingly difficult central tasks and faster presentation speeds is repeated methodically, until the participants can perform both the central identification task and the peripheral localization task with approximately 15% accuracy, at an average presentation speed of 50 ms or less.

Upon reaching the training criterion for divided attention tasks, training participants progress to training on selective attention tasks. These tasks require the simultaneous performance of a central task (color, identification, or target direction) and localization of a peripheral target that is embedded in distractors. Training on selective attention tasks begins at a display duration that is the individual threshold with the peripheral target placed at the nearest eccentricity. As described above, while the participant is able to perform the training task correctly 75% of the time at longer display durations, we seek to find more demanding by decreasing display duration and either manipulating the central task difficulty, peripheral target eccentricity, or both. Manipulations of peripheral target color and direction/linearity also are used as means of tailoring the peripheral task to appropriate levels of difficulty for each individual. Practice on selective attention tasks is continued until mastery level of 75% correct performance is achieved at an average display duration of 80 ms or less with peripheral targets at the most recent eccentricity, or until test training sessions have been completed.

Speed of Processing Intervention

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (n = 47)</th>
<th>Training (n = 44)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glaucoma</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Cataract</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Macular degeneration</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Retinal detachment</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Diabetic retinopathy</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Optic neuropathy</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Dry eye syndrome</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Heart disease</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Hypertension</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Alzheimer’s</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Depression</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Cancer</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Stroke</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other conditions</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

Results

The 69 participants who completed both pre- and post-test assessments were included in subsequent analyses. In order to include all of these cases in analyses, substitutions for missing data points were made in the following manner: participants who had completed a measure at pretest, but were missing a posttest score, were assigned their pretest value on the appropriate measure. If both pre- and posttest values were missing for a participant on a particular measure, the overall pretest mean was assigned for both of the missing values. Less than 7% of the data points were missing prior to these substitutions. Consistent with the fact that all participants completed the same number of trials of the Road Sign Test; (2) there was no change in test version from pre- to posttest for any participants; (3) equivalent proportions of the control group and training group received each version of the test; (4) n = 91 = 0.976, p = 0.233, and (4) there were no baseline differences between the training and control groups on the task, we examined performance collapsed across versions rather than assigning missing values, for the 15 participants who completed the revised version of the test.

Self-reported frequencies of eye and medical conditions are presented in Table 2 by group. Chi-square analyses revealed no significant differences between the training and control groups in the frequency of any of these health conditions (all p values >.05).

### Table 3: Dependent measures before and after training by group (mean ± SD)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control group (n = 47)</th>
<th>Training group (n = 46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactual Field of View</td>
<td>47.19 ± 26.67</td>
<td>38.58 ± 19.79</td>
</tr>
<tr>
<td>Tactile Sign Test</td>
<td>1.85 ± 0.47</td>
<td>1.34 ± 0.12</td>
</tr>
<tr>
<td>Timed tADL</td>
<td>-0.07 ± 0.49</td>
<td>0.03 ± 0.58</td>
</tr>
<tr>
<td>Finding As</td>
<td>23.10 ± 5.7</td>
<td>23.87 ± 5.1</td>
</tr>
<tr>
<td>Identical Parity</td>
<td>24.08 ± 4.60</td>
<td>24.17 ± 6.42</td>
</tr>
<tr>
<td>Cetve/Pattern Comparison</td>
<td>66.11 ± 15.21</td>
<td>67.33 ± 24.46</td>
</tr>
<tr>
<td>Digit Symbol</td>
<td>1.27 ± 0.65</td>
<td>1.19 ± 0.54</td>
</tr>
<tr>
<td>Stroke</td>
<td>2.16 ± 1.17</td>
<td>19.42 ± 1.81</td>
</tr>
<tr>
<td>Trails</td>
<td>49.14 ± 24.51</td>
<td>62.13 ± 30.10</td>
</tr>
<tr>
<td>Controlled Oral Word Association</td>
<td>37.72 ± 13.50</td>
<td>41.60 ± 11.89</td>
</tr>
<tr>
<td>Benton Visual Retention</td>
<td>5.73 ± 2.17</td>
<td>5.72 ± 2.25</td>
</tr>
<tr>
<td>Rey-Osterrieth Complex Figure</td>
<td>11.09 ± 3.58</td>
<td>17.03 ± 0.11</td>
</tr>
<tr>
<td>Digit Span</td>
<td>9.10 ± 2.65</td>
<td>9.38 ± 2.96</td>
</tr>
<tr>
<td>Facial Recognition</td>
<td>43.80 ± 7.01</td>
<td>45.55 ± 9.49</td>
</tr>
<tr>
<td>WAIS-R Inhibition</td>
<td>11.62 ± 2.91</td>
<td>12.65 ± 2.86</td>
</tr>
<tr>
<td>Block Design</td>
<td>7.51 ± 2.36</td>
<td>8.00 ± 2.25</td>
</tr>
</tbody>
</table>

* Lower values reflect better performance for these measures.

Multivariate analysis of variance was also conducted in order to determine whether there were differences between the training and control groups at the baseline assessment. Age, years of education, and prettest performance were measures of speed processing (UFOM, Road Sign Test, Timed tADL, Finding As, Identical Parity, Cetve/Pattern Comparison, Digit-Symbol Substitution); executive function (Stroke, Trail Making Test, Controlled Oral Word Association); memory (Benton Visual Retention, Rey-Osterrieth Immediate Recall, WAIS-R Digit Span); visual-spatial skills (Facial Recognition and Block Design); and crystallized intelligence (WAIS-R Information) were the dependent variables, and group membership was the independent variable. There was no significant main effect of group. Thus, overall no significant differences between the two groups at pretest were found: Wik's Λ = 0.824, F(7, 73) < 1, p = 0.556. The mean values and standard deviations for the dependent measures are presented in table 3.

Since there was such a wide range of educational levels (6–29 years), and the degree of education is known to impact several of the cognitive domains tapped by the dependent measures (54), education was used as a covariate in subsequent analyses. Multivariate analysis of covariance was conducted in order to compare the two groups' overall performance across testing occasions on the measures of speed of processing, executive function, memory, visual-spatial skills, and crystallized intelligence. Group membership (train vs. control) was the independent variable, and the 16 dependent cognitive measures across two visits were examined. The results revealed that after controlling for education level, there was significant interaction between cognitive measures, testing occasion, and group: Wik's Λ = 0.670, F(17, 71) = 2.328, p = 0.009. The two groups performed differently across testing occasions and cognitive measures.

In order to further investigate this significant interaction, the multivariate analysis of covariance was followed up with 16 univariate analyses of covariance. In order to hold the influence of education and prettest performance constant, these variables were used as covariates. Group membership was the independent variable, and performance on the measure of interest was the dependent variable.

As expected, after adjustment for education level and prettest UFOM performance, a significant male effect of group was found for positronic performance on the inner transfer measures: UFOM F(1, 87) = 37.89, p < 0.001. UFOM performance at pretest was a significant covariate: F(1, 87) = 200.024, p < 0.001. However, education was not: F(1, 87) = 2.621, p = 0.109. After controlling for education and prettest UFOM performance, those who com-
pleted speed of processing training performed significantly better at posttest on the UROV than did the control group.

A significant main effect of group was also found for Timed IADL posttest performance: F(1, 87) = 3.93, p = 0.049. Both education and prettest performance were significant covariates for posttest Timed IADL performance: F(1, 87) = 82.55, p < 0.001 and F(1, 87) = 9.77, p = 0.002. Overall, after adjusting for education and prettest Timed IADL performance, the trained group performed better on the Timed IADL task at posttest than did the control group.

The training and control groups also performed significantly different at posttest on Controlled Oral Word Association after adjusting for education and prettest performance on the measure: F(1, 87) = 5.91, p = 0.017. However, for this task, the control group performed better than the training group. While performance at pretest was a significant covariate for posttest performance: F(1, 87) = 216.79, p < 0.001, education was not: F(1, 87) = 2.25, p = 0.114. Whereas the training group experienced essentially no change in the number of words produced for the verbal fluency task (from pre- to postassessment), the control group, on average, produced four more words at posttest than at pretest (table 3).
No other significant main effects of group were found for any of the other dependent variables (p values > 0.05). Present was a significant predictor of posttest performance for all of the other dependent variables (p values < 0.001). Education was a significant covariate for posttest performance on Digit-Symbol substitution, Identical Pictures, Letter/Pattern Comparison, Stroop, and WAIS information (p values < 0.05). The mean values and standard deviations for all dependent measures are presented in table 3.

The relatively small magnitude of the training effects found in the present study led us to examine select factors that could potentially account for these results. Specifically, we were interested in the relationship between education, initial speed of processing ability, and age, to the amount of gain evidence after training. For the speed of processing training participants, we examined the relationships among these variables. Scatterplots illustrating the relationships between baseline UFOV, age, education, and training gains are presented in figure 1. There is a wide range of education in the sample (fig. 1a, b). However, education was not related to training gain (fig. 1a) or baseline UFOV performance (fig. 1b). Similarly, age was not associated with training gain (fig. 1c). The only significant predictor of training gain was initial speed of processing performance (fig. 1d).

Discussion

The primary goal of the present study was to evaluate the extent of transfer of speed of processing training to multiple speed of processing measures, as well as to measures of other domains of cognitive functioning. Initial results revealed a training effect upon the UFOV measure and a transfer of the training effect to Timed IADL performance.

These results, however, were somewhat surprising given that training results obtained in prior studies have been of a greater magnitude and have found transfer to the Road Sign Test [8]. For example, in the most recent study [8], trained participants were 2.5 standard deviations faster following training relative to the control group, on the composite UFOV score. In the current sample, the effect size for the composite UFOV measure was only 0.62 standard deviations as a result of the large range of education in the sample. It is important to note that the sample size of the present study (speed training n = 44) is comparable to the sample size of this previous training study (speed training n = 49).

The methodological differences between the present and prior studies are the most likely explanation for these discrepancies. First of all, the present study employed group training with a fixed number of training sessions as opposed to individual training to criteria as done previously [8]. We wanted to evaluate the feasibility of conducting speed of processing training in groups as opposed to one-to-one, as had been done previously. Through the present study, we discovered that this method of training flowed smoothly and that our trainers were able to work with groups of 2-3 participants at a time. This was of interest because if speed of processing training proves to be an effective intervention for older adults, administering the training to groups would be more practical and economical to implement. Further research will specifically aim at comparing the effectiveness of group versus individualized training methods. Second, whereas previous studies have only included individuals with initial difficulty in speed of processing, as assessed by the UFOV [8], the present study included individuals regardless of their baseline speed of processing skills. We found that individuals who are initially having difficulty with speed of processing, as assessed by UFOV, are more likely to benefit from training (see fig. 1). However, it is important to consider that the present study only examined the short-term impact of training. It may be the case that individuals who do not have baseline speed of processing difficulties show long-term benefits rather than significant short-term changes. Ongoing research is aimed toward investigating this possibility.

As previously mentioned, the present study included a more diverse sample of older adults than have prior studies. Inclusion criteria were minimal in order to investigate the impact of the training in a more representative sample of the general 65 years and older population. A weakness of the present study is that no comprehensive screening assessment for dementia was included. It is possible that some of the participants could have suffered from pathology that may have interfered with their ability to improve with training. For example, Bates et al. [58] found that older persons who were at risk of Alzheimer's disease showed no gains with cognitive training, whereas all normal participants did improve with training. Similarly, the present study sample could have included a few individuals at risk of dementia or who had suffered from recent stroke, and inclusion of such individuals could have also contributed to the lack of transfer. Unfortunately, these issues cannot be addressed by the current study. Overall, further research should aim to identify who potentially may (e.g., individuals with speed of processing deficits)
and may not (e.g., individuals with or at risk for demen-
tia) benefit from training.

In summary, the results of this study are consistent with results of previous research, indicating that speed of processing training led to improvements in UPDRS performance. Also, the results are consistent with previous speed of processing, memory, and reasoning training studies, in which training effects did not transfer to mea-
sures in other domains of cognitive functioning [8, 15, 18].

Even though there was an overall lack of transfer of training to cognitive measures, the significant impact of training upon Tidan performance is promising. This finding is consistent with the notion that, in general, everyday performance is more strongly related to fluid abilities than to crystallized intelligence [56]. Specifically, the fluid abilities of memory span [57] and speed of pro-
cessing [31, 57] have been shown to affect older adults' performance of IADLs. Thus, interventions that improve or maintain fluid abilities might be expected to enhance or extend older adults' independent daily functioning. Furthermore, it is encouraging that these significant training effects were found with a general sample of community-
ized-dwelling older adults rather than a restricted sample selected to optimally benefit from training.

These results indicate that there is potential for speed of processing training to enhance the everyday functioning of older adults. Determining the most effective meth-
ods of administering the training and identifying the spe-
cific populations who will most benefit from this training are goals for further investigation.

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