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Introducing Demographic-Corrections for the 10/36 Spatial Recall Test

Adam Gerstenecker, PhD¹, Roy Martin, PhD¹, Daniel C. Marson, PhD, JD¹, Khurram Bashir, MD, MPH², and Kristen L. Triebel, PsyD¹

¹Department of Neurology, Division of Neuropsychology, University of Alabama at Birmingham, USA

²Department of Neurology, Division of Neuroimmunology and Multiple Sclerosis, University of Alabama at Birmingham, USA

Abstract

Objective—The 10/36 Spatial Recall Test is a measure of visuospatial memory and has been recommended for inclusion when administering a brief cognitive assessment to patients with multiple sclerosis by multiple groups. However, a notable limitation of the measure includes a lack of normative data with demographic corrections. Thus, the primary objective of the current study was to examine demographic influences on the 10/36 Spatial Recall Test and to introduce demographically-corrected normative data for the instrument.

Methods—Data were collected from 116 participants over the age of 50 years. All study participants were free of any neurologic disease or disorder and classified as cognitively intact by a consensus conference team that was comprised of neurologists and neuropsychologists. All study participants were administered a neuropsychological evaluation that included the 10/36 Spatial Recall Test Version A at the baseline visit.

Results—10/36 Spatial Recall Test scores were affected by age, education, and race. Gender effects were not observed. Given these effects, regression equations were used to correct for the effects of demographic variables. The z-scores obtained from these corrections were not significantly influenced by demographical variables.

Conclusion—The demographic-corrections introduced in this paper offer the possibility to enhance the clinical utility of the 10/36 Spatial Recall Test.

Introduction

The 10/36 Spatial Recall Test (SPART; Rao, 1990) is a measure of visuospatial memory. Given its relatively low motoric demands, the SPART is well designed for use with patients with certain types of movement disorders. For instance, the SPART has been recommended for inclusion when administering a brief cognitive assessment to patients with multiple sclerosis (MS) (Langdon et al., 2012), is part of the Brief Repeatable Battery of

Corresponding Author: Adam Gerstenecker, PhD, Department of Neurology, University of Alabama at Birmingham, Sparks Center 650, 1720 7th Avenue South, Birmingham, Alabama 35294-0017. Phone: (205) 934-2334, Fax: (205) 975-3094. atgers@uab.edu.

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Neuropsychological Tests developed by the Cognitive Function Study Group of the National Multiple Sclerosis Society (Rao, 1990), and has been used in multiple double-blind clinical trials of potential MS treatments (Camp et al., 1999; Hohol et al., 1997; Smits et al., 1994; Sperling et al., 2001; Weinstein et al., 1999).

In previous studies, the SPART has been shown to be one of the most sensitive measures for detecting memory impairment in patients with MS (Dent & Lincoln, 2000). Patients with MS have been shown to perform poorer than healthy controls on the SPART, with people with the relapsing-remitting subtype and secondary progressive subtype performing poorer than those with the primary progressive subtype (Huijbregts, Kalkers, de Sonnevile, de Groot, & Polman, 2006). In addition to MS, the SPART has also been used in samples of patients with radiologically isolated syndrome (Amato et al., 2012), amnesic mild cognitive impairment (Griffith et al., 2013), and brain tumor (Torres et al., 2003).

Although data exists that allows clinicians working with the SPART to make rudimentary normative conversions using a z-score equation (Boringa et al., 2001; Camp, et al., 1999), a notable limitation of the measure includes a lack of normative data with demographic corrections. In a previous study that utilized a sample of healthy adults, SPART scores and age were shown to negatively correlate but SPART performance was not significantly affected by education (Boringa, et al., 2001). However, in the same study, education was divided by group (i.e., <9 years, 9–10 years, and >10 years) and not examined as a continuous variable. SPART scores tend not to vary by gender (Boringa, et al., 2001).

Given that normative data with demographic-corrections are not available for the SPART, the purpose of the current study was to examine demographic influences on the measure and to generate demographically-corrected normative data for the instrument. It was expected that age would be inversely related to SPART scores. It was also hypothesized that, when expressed as a continuous variable, education would show a positive correlation with SPART scores. Finally, although previous investigations into the effects of race have not been conducted specifically for the SPART, race has been shown to affect performance on neuropsychological test performance (Lewis-Jack, et al., 1997; Lucas, et al., 2005; Lucas, 2003). Therefore, SPART performance was expected to vary according to race. Effects of gender were not anticipated.

Method

Participants

Following institutional review board approval and obtainment of informed consent, data collected from 116 participants were analyzed in this study. Study participants were recruited as part of a longitudinal study of functional change in MCI (Cognitive Observations in Seniors) (COINS) (1R01 AG021927) taking place at the University of Alabama at Birmingham (UAB). COINS participants have previously been described in detail (Triebel et al., 2009). For inclusion in the current study, participants needed to have completed a baseline evaluation that included the SPART. To add uniformity to potential demographic corrections based on race, only data collected from Caucasian and African-American participants were analyzed in this study.

All study participants were free of any neurologic disease or disorder and classified as cognitively intact by the Alzheimer's Disease Research Conference (ADRC) diagnostic team at the University of Alabama at Birmingham (UAB), which consisted of neurologists, neuropsychologists, and nurses. To be considered for inclusion as a "healthy" control, participants were required to meet the following criteria: 1) absence of diseases or conditions that could potentially affect cognition, including psychiatric disorder (except mild depression), substance abuse, cerebrovascular disease, or other neurologic diseases (based on record review and self-report); 2) absence of findings on physical examination suggestive of problems with cognition; and 3) absence of the use of medications known to affect cognition. Thus, participants are believed to represent a sample comparative to adults living independently in the community. UAB conference ratings were initially independent. However, if divergent diagnostic impressions existed between various conference members, discussion ensued until a unanimous consensus was achieved.

Measures

As previously mentioned, the SPART is a measure of visuospatial memory. To administer the SPART, a 6×6 checker board and 10 checkers are used. To begin, a checkerboard containing a pattern of checkers is placed in front of the examinee for 10 seconds. After the initial presentation, the examinee attempts to reproduce the design using a blank checkerboard and 10 checkers. The process is repeated two more times and then followed by a delay condition after the passage of 15 minutes. SPART Immediate Recall score is the product of the total number of correct responses (i.e., number of correct checkers) for the three learning trials. SPART Delayed Recall score is the total number of correct responses (i.e., number of correct checkers) in the delay condition. Two versions of the SPART (i.e., Versions A and B) are available and allow for repeated testing.

Statistical Analyses

First, the influence of demographic variables (i.e., age, education, gender, ethnicity) on SPART Immediate and Delayed Recall scores were examined. Pearson product moment correlations were used to examine age and education and independent t-tests were used to examine gender and race (Caucasian and African-American). Statistically significant demographic variables from the first step were then used in the second analysis. For this analysis, two separate stepwise linear regressions were used to predict SPART Immediate Recall and SPART Delayed Recall scores. Stepwise regression has previously been used in neuropsychology to develop demographic corrections and to predict cognitive change across time (Duff, Shprecher, Litvan, Gerstenecker, & Mast, 2014; Heaton, Grant, & Matthews, 1991; McSweeny, Naugle, Chelune, & Luders, 1993). Thus, this form of regression analysis was chosen over other regression methods (e.g., hierarchical regression). Demographically-corrected z-scores were then evaluated for their influence on SPART scores in the same manner described above. A two-tailed alpha level of .05 was used.

Results

Sample Characteristics

The sample consisted of 41 men and 75 women with a mean age of 67 years ($SD = 8.2$, range = 50–86) and a mean education of 15 years ($SD = 2.7$, range = 6–20). The sample was either Caucasian (72.4%) or African-American (27.6%). Mean SPART scores were 17.8 ($SD = 4.8$) for Immediate Recall and 5.9 ($SD = 2.3$) for Delayed Recall.

Influences of Demographic Variables

Age negatively correlated ($r = -.22$, $p = .202$) and education positively correlated ($r = .23$, $p = .015$) with SPART Immediate Recall scores. Education also positively correlated with SPART Delayed Recall scores ($r = .21$, $p = .023$). Age was not significantly correlated with SPART Delayed Recall scores ($r = -.12$, $p = .016$). Neither SPART Immediate nor Delayed Recall scores varied by gender ($t[114] = .35$, $p = .730$ and $t[114] = .46$, $p = .645$, respectively). Both SPART Immediate and Delayed Recall scores varied by race ($t[114] = 3.1$, $p = .003$ and $t[114] = 2.7$, $p = .009$, respectively).

Demographic Corrections

In the final, stepwise regression model for SPART Immediate Recall, age, education, and race accounted for approximately 18% of variance in scores ($F[3,112] = 8.1$, $p < .001$, $R^2 = .18$). Each step of the regression model used to correct for demographic variables for SPART Immediate Recall can be found in Table 1. All assumptions of regression were met for this model including normality of residuals (*Shapiro-Wilk*[116] = .99, $p = .834$). In the final, stepwise regression model for SPART Delayed Recall, education and race accounted for approximately 9% of variance in scores ($F[3,112] = 5.4$, $p = .006$, $R^2 = .09$). Each step of the regression model used to correct for demographic variables for SPART Delayed Recall can be found in Table 2. All assumptions of regression were met for this model including normality of residuals (*Shapiro-Wilk*[116] = .99, $p = .593$). The formulas derived from the regression modeling of these demographic corrections can be found in Tables 3 and 4.

When analyzing demographically-corrected z-scores, neither age nor education were significantly related to SPART Immediate Recall ($r = -.01$, $p = .961$ and $r = -.01$, $p = .959$, respectively). In addition, demographically-corrected z-scores for SPART Immediate Recall did not significantly vary according to race ($t[114] = -.08$, $p = .938$). For SPART Delayed Recall, the application of demographically-corrected z-scores caused education to no longer be significantly correlated ($r = -.01$, $p = .936$). Moreover, demographically-corrected z-scores for SPART Delayed Recall did not significantly vary according to race ($t[114] = -.03$, $p = .977$). SPART Immediate and Delayed Recall z-scores did not show significant skewness ($-.032$ and $-.077$, respectively) or kurtosis ($-.472$ and $-.462$, respectively).

Discussion

The SPART is a measure of visuospatial learning and memory that has been used in numerous patient populations and has shown particular utility when evaluating the cognitive abilities of patients with MS. The SPART has been recommended for inclusion when

administering a brief cognitive assessment to patients with multiple sclerosis (MS) (Langdon, et al., 2012), is part of the Brief Repeatable Battery of Neuropsychological Tests developed by the Cognitive Function Study Group of the National Multiple Sclerosis Society (Rao, 1990), and has been used in multiple double-blind clinical trials of potential MS treatments (Camp, et al., 1999; Hohol, et al., 1997; Smits, et al., 1994; Sperling, et al., 2001; Weinstein, et al., 1999). However, normative data that corrects for demographic variables are not available for this measure and could lead to the inaccurate interpretation of scores. Consistent with a previous study (Boringa, et al., 2001), we found significant effects of age and race on both SPART Immediate and Delayed Recall scores, with younger participants and Caucasian participants performing better. In addition, we also observed SPART Immediate Recall scores to vary according to education, with those participants with more education performing better than those participants with less education.

Because SPART scores varied according to the demographic characteristics of the sample, we next introduced normative corrections for demographic variables. To accomplish this goal, we used regression modeling, as it has been previously established as a useful method of conducting normative demographic-corrections (Duff, et al., 2014; Heaton, et al., 1991). For SPART Immediate Recall scores, all of age, education, and race were significant predictors. For SPART Delayed Recall scores, education and race were significant predictors. Taken together, demographic information accounted for 18% and 9%, respectively, of SPART Immediate and Delayed Recall scores in this sample of healthy older adults with intact cognition. These demographic corrections minimize systematic error and, thus, enhance the accuracy of the measure. In addition, the corrections for race introduced in this paper make the findings more generalizable to the African-American population and have potential to limit the number of African-Americans misclassified as cognitively impaired.

Despite independent clinical and external validation of the demographic corrections introduced in this paper being beyond the scope of this study, an examination of the utility of these corrections can be conducted using this sample. For example, SPART Immediate Recall scores varied significantly according to age, education, and race. However, when examining demographically-corrected z-scores, age and education were no longer related to SPART Immediate recall scores and scores did not vary according to race. This same pattern can be seen for SPART Delayed Recall. For instance, SPART Delayed Recall scores varied according to education and race. However, when examining demographically-corrected z-scores, the effects of education and race on SPART Delayed Recall scores were minimal. Taken together, these post-hoc analyses show that the demographic-corrections introduced in this paper remove a significant amount of confounding variance in SPART scores for this sample.

Examples of how to conduct demographic-corrections may be useful for some clinicians (see Tables 5 and 6). In this study sample, the mean age was 67 years, the mean education was 15 years, and most participants were Caucasian. Using the formula introduced in Table 3 for SPART Immediate Recall and the sample averages/characteristics listed above, the predicted score for this sample would be 18.8 and slightly greater than the observed score of 17.8. This score is indicative of average performance on SPART Immediate Recall. Using

these same sample averages and the formula to make demographic-corrections for SPART Delayed Recall (Table 4), the predicted score for this sample would be 6.2 and again be slightly higher than the observed score of 5.9. This score is indicative of average performance for SPART Delayed Recall. Demographic corrections can also be made at the individual level. For a 68-year-old Caucasian with 13 years of education that scored an 11 on SPART Immediate Recall, the predicted score would be seven points higher (i.e., $28.77 - [1 * 3.28] - [68 * 0.16] + [13 * 0.27] = 18$). However, for an African-American with 14 years of education that scored a 10 on SPART Delayed Recall, the predicted score would be five points lower (i.e., $5.04 - [2 * 1.07] + [14 * 0.15]$).

To fully utilize these demographic-corrections, however, another step is required. By dividing the difference of observed SPART and predicted SPART scores by the standard error of the estimate of the regression models introduced in Tables 3 and 4, a z-score is calculated for each patient that shows how many standard deviation units he/she is away from his/her predicted score. For Example 2 in Table 5 (i.e., 68-year-old Caucasian with 13 years of education), the observed score of 11 on SPART Immediate Recall is 1.56 standard deviation units lower than expected given the person's demographic characteristics (i.e., $[11 - 18] / 4.5 = -1.56$). This obtained z-score of -1.56 would fall at the 6th percentile and be considered mildly impaired in relation to peers of the same race, education, and age. For Example 1 in Table 6 (i.e., African-American with 14 years of education), the observed score of 10 on SPART Delayed Recall is 2.29 standard deviation units greater than expected given the person's demographic characteristics (i.e., $[10 - 5] / 2.18 = 2.29$). This obtained z-score of $+2.29$ would fall at the 99th percentile and be considered very superior in relation to peers of the same race and education. Z-scores for both SPART Immediate and Delayed Recall were normally distributed, making their interpretation easier. For those interested, an Excel spreadsheet can be obtained from the first author of this study that can be used to make these calculations.

There are a number of limitations and future directions to be considered. First, like most other studies taking place in a university-based hospital, the current sample may not be representative of the general population of community dwelling adults. Participants needed to agree to engage in several hours of testing and undergo a neurological exam. This likely yields a select group of participants who were included in this study. Second, clinical validation of the formulas introduced in this paper was beyond the scope of this study, and external validation is needed. Third, the sample used to construct these demographic-corrections was comprised of adults over the age of 50. Taken together, these three limitations indicate that future studies should examine the utility of the formulas presented in this paper in more samples and in more diverse samples. In addition, the relationship between education and performance on the SPART was examined in this study. However, education may have served as a proxy for intelligence in this study. Thus, future studies should examine the relationship between estimates of intelligence and SPART scores. Regardless, the demographic-corrections introduced in this paper offer the possibility of enhancing the clinical utility of the 10/36 Spatial Recall Test.

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Table 1

Results of the stepwise regression for SPART Immediate Recall.

Step	F; df; <i>p</i>	R ²	SEE	β, SE
1	9.5; 115; 0.003	0.08	4.7	
Race				−2.98, 0.97
Constant				21.6, 1.31
2	10.6; 115; <0.001	0.16	4.5	
Race				−3.61, 0.95
Age				−0.17, 0.05
Constant				33.95, 3.94
3	10.2; 115; <0.001	0.18	4.5	
Race				−3.28, 0.96
Age				−0.16, 0.05
Education				0.27, 0.16
Constant				28.77, 4.97

Note. Race=1 for Caucasian and 2 for African-American. SPART=10/36 Spatial Recall, SEE = standard error of the estimate of the regression model, β = unstandardized beta weights, SE = standard error of coefficient.

Table 2

Results of the stepwise regression for SPART Delayed Recall.

Step	F; df; <i>p</i>	R ²	SEE	β, SE
1	7.2; 115; 0.009	0.06	2.21	
Race				-1.23, 0.46
Constant				7.45, 0.62
2	25.8; 115; 0.006	0.09	2.18	
Race				-1.07, 0.46
Education				0.15, 0.08
Constant				5.04, 1.42

Note. Race=1 for Caucasian and 2 for African-American. SPART=10/36 Spatial Recall, SEE = standard error of the estimate of the regression model, β = unstandardized beta weights, SE = standard error of coefficient.

Table 3

Prediction Equation for SPART Immediate Recall.

Prediction equation	SEE
10/36 Spatial Immediate Recall Predicted = $28.77 - (\text{Race} \times 3.28) - (\text{Age} \times 0.16) + (\text{Education} \times 0.27)$	4.5

Note. Race=1 for Caucasian and 2 for African-American. Age and education are in years. SPART=10/36 Spatial Recall, SEE=standard error of the estimate.

Table 4

Prediction Equation for SPART Delayed Recall.

Prediction equation	SEE
10/36 Spatial Delayed Recall Predicted = $5.04 - (\text{Race} * 1.07) + (\text{Education} * 0.15)$	2.18

Note. Race=1 for Caucasian and 2 for African-American. Education is in years. SPART=10/36 Spatial Recall, SEE=standard error of the estimate.

Table 5

Case Examples for SPART Immediate Recall

Example 1: 63-year-old Caucasian with 18 years of education scoring a 26 on SPART Immediate Recall
SPART Immediate Recall Predicted = $28.77 - (\text{race} \times 3.28) - (\text{age} \times 0.16) + (\text{education} \times 0.27)$
SPART Immediate Recall Predicted = $28.77 - (1 \times 3.28) - (63 \times 0.16) + (18 \times 0.27)$
SPART Immediate Recall z-score = $(\text{observed} - \text{predicted}) / \text{SEE}$
SPART Immediate Recall z-score = $(26 - 20) / 4.5 = +1.33$
Example 2: 68-year-old Caucasian with 13 years of education scoring an 11 on SPART Immediate Recall
SPART Immediate Recall Predicted = $28.77 - (\text{race} \times 3.28) - (\text{age} \times 0.16) + (\text{education} \times 0.27)$
SPART Immediate Recall Predicted = $28.77 - (1 \times 3.28) - (68 \times 0.16) + (13 \times 0.27)$
SPART Immediate Recall z-score = $(\text{observed} - \text{predicted}) / \text{SEE}$
SPART Immediate Recall z-score = $(11 - 18) / 4.5 = -1.56$

Note. Race=1 for Caucasian and 2 for African-American. SPART=10/36 Spatial Recall, SEE=standard error of the estimate.

Table 6

Case Examples for SPART Delayed Recall

Example 1: African-American with 14 years of education and an observed SPART Delayed Recall score of 10
SPART Delayed Recall Predicted = $5.04 - (\text{Race} * 1.07) + (\text{Education} * 0.15)$
SPART Delayed Recall Predicted = $5.04 - (2 * 1.07) + (14 * 0.15)$
SPART Delayed Recall z-score = $(\text{observed} - \text{predicted}) / \text{SEE}$
SPART Delayed Recall z-score = $(10 - 5) / 2.18 = +2.29$
Example 2: Caucasian with 14 years of education and an observed SPART Delayed Recall score of 3
SPART Delayed Recall Predicted = $5.04 - (\text{Race} * 1.07) + (\text{Education} * 0.15)$
SPART Delayed Recall Predicted = $5.04 - (1 * 1.07) + (14 * 0.15)$
SPART Delayed Recall z-score = $(\text{observed} - \text{predicted}) / \text{SEE}$
SPART Delayed Recall z-score = $(3 - 6) / 2.18 = -1.38$

Note. Race=1 for Caucasian and 2 for African-American. SPART=10/36 Spatial Recall, SEE=standard error of the estimate.