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REVIEW ARTICLE

Selecting the Appropriate Memory Test for Patients with Stroke: Criterion Validity of the Buschke Selective Reminding Test

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ABSTRACT

Accurate assessment of memory following a stroke is important for patient rehabilitation. The Buschke Selective Reminding Test (SRT) is a test of verbal learning and memory that can be used to assess many clinical populations. The current study investigated the criterion validity of the SRT by comparing scores from patients with stroke to healthy controls, and identified scores on the SRT that best differentiate between these two groups. Participants included 65 patients with stroke and 65 age-and education-matched healthy controls. The control group differed significantly from patients with stroke on all scores (p <.01). Spearman's rho correlations revealed potential multicollinearity between multiple SRT measures. Binomial logistic regression suggested SRT scores differentiated patients with stroke from controls, and correctly classified 76% of cases. Lower continuous long-term retrieval (CLTR) scores were more likely among patients with stroke. Results supported the SRT as useful for identifying verbal learning and memory impairment in acute stroke inpatients.

Keywords: Memory, Neuropsychological Assessment, Stroke, Psychometrics, Selective Reminding Test

Introduction

Stroke impacts over 25 million people worldwide and remains a leading cause of physical disability, neurological disability, and death (Oni et al., 2018). It is well-established that deficits in verbal learning and memory are common after stroke (American Stroke Association, 2013; Lezak, Howieson, Bigler, & Tranel, 2012; Maud, 2006; Reitz, Luchsinger, & Tang, 2006; Rasquin et al., 2002; Levine et al., 2015; Al-Qazzaz et al., 2014; Lansing et al., 2004; Nys et al., 2007; Snaphaan & de Leeuw, 2007). Moreover, stroke increases the risk of developing dementias (e.g., vascular dementia) that are also associated with memory impairment (Cullen et al., 2007; Pendlebury & Rothwell, 2009). Given the propensity for verbal learning and memory deficits post-stroke, the accurate assessment of memory deficit severity in patients with stroke is necessary.

The assessment of memory can help identify the type(s) of memory impaired and how to best intervene during rehabilitation (Al-Qazzaz et al., 2014). As memory disruption is associated with decreased functional outcome after stroke, understanding the severity and type of memory impairment is necessary to develop appropriate patient care plans (Barker & Feigin, 2006). The National Institute of Neurological Disorders – Canadian Stroke Network have suggested in their guidelines that memory is one of four cognitive domains that should be assessed after stroke (Hachinski, et al., 2006); however, the neuropsychological assessment of memory requires careful consideration of which test to employ. A recent survey by Rabin and colleagues (2016) reported that approximately 96 neuropsychological measures are available that include an assessment of memory and 14 are specific to the assessment of memory.

Given the vast selection of measures available to assess memory, it is paramount that the psychometric properties of these measures are rigorously reviewed to inform test selection and ensure the most valid and reliable results for patients and referral sources. However, caution is warranted that even the most widely employed tests suffer from inadequate psychometric evaluation or require updating (Strauss, Sherman, & Spreen, 2006). Given the change in testing context and populations over time, the validity of tests must also be re-evaluated; recommendations are that psychometric properties of tests should be updated at least every 10 years (Nunally & Bernstein, 1994; Weiss, 2016). Moreover, replication of studies examining the validity of memory tests is crucial to assess the reliability of findings across studies, populations, and settings.

Common cognitive screening methods include the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005); common neuropsychological assessments of memory include the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964), the California Verbal Learning Test (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000), and verbal selective reminding tests. Research has demonstrated that verbal selective learning tests can be the most sensitive and useful in measuring early forms of dementia and healthy controls (Larrabee, Largen, & Levin, 1985; Weingartner et al., 1983). The risk of developing dementia increases within the first year after a stroke, with memory being a common deficit in these populations (Al-Wazzaz et al., 2014).

To date, a review of studies investigating the criterion validity of measures following acute stroke found that the MoCA, MMSE, and Higher Cortical Function Deficits Test (Hoffmann, 2001) were above sensitivity and specificity levels of 80% and 60%, respectively, for differentiating between stroke and healthy controls (Van Heugten, Walton, & Hentschel, 2015); however, some research suggests that the MMSE is not sensitive to detecting mild forms of dementia or cognitive impairment (Spencer et al., 2013). Further, studies demonstrate that while the MoCA shows stronger correlations to specific neuropsychological assessments for memory in patients with stroke (Pendlebury et al., 2010), there is still a need for more sensitive and robust tests to distinguish between healthy controls and those with mild cognitive impairment (Whitney et al., 2012). Therefore, it is not only important to investigate memory after stroke, but also the test that is being used, in order to develop an accurate baseline in the early stages of recovery.

Studies examining neuropsychological test results of patients with multiple sclerosis to healthy matched controls found that patients scored significantly lower on the Buschke Selective Reminding Test (SRT; Buschke, 1973) composite scores for immediate- and delayed-recall, as well as consistent long-term retrieval (Radomski et al., 2015). Campo et al (2003) found that the SRT differentiated between healthy controls and elderly adults with dementia. As well, the SRT has been shown to differentiate between mild dementia and normal aging (Masur et al., 1989). Collectively these studies suggest differences in scores between healthy controls and clinical populations; however, there has not been a study that directly investigated the criterion validity of the SRT in a stroke inpatient population. Given the prevalent and dynamic nature of memory impairments with varying severity following stroke, it is important to assess the utility of the SRT in this setting.

The SRT (Buschke, 1973) is a test of verbal learning and memory that assesses components of encoding, storage, and retrieval. The SRT has several different iterations including a 6-word, 8-word, and 12-word list version and alternate word lists for each version (Strauss, Sherman, & Spreen, 2006). For the 12-word list version, patients are initially read a list of 12 words and are asked to repeat back as many as they can remember. Following each trial, the patient is told of the words they missed on the list. The patient is then instructed to recite back the entire list of words (including the words they initially repeated). This process is repeated for 12 trials or discontinued if the patient is able to recall all the words on 3 consecutive trials. Following completion of 12 or less trials, the patient is then provided with the first few letters of each word on the list and ask to recall the word. The patient is next presented with four words (one of the four words is a word on the list) and asked to identify which of the four words was on the list. Scores are provided for words recalled (and missed), long term storage (LTS), long-term retrieval (LTR), consistent long-term retrieval (CLTR), inconsistent or random long-term retrieval (RLTR), short term recall (STR), immediate cued- and multiple-choice recall, as well as long-delay (30-min) free recall and cued- and multiple-choice recall. Overall, the SRT has been found to assess verbal learning in a manner that is more challenging than other list learning measures (Larrabee et al., 1985).

The SRT can provide valuable insight into memory deficit severity that has important clinical value. Beatty et al. (1996) found that words entering CLTR during trials 1 to 12 (acquisition) were more likely to be recalled on the 30-minute delay. The SRT has demonstrated sensitivity to many clinical conditions: differentiating between stroke location (Campbell, Leitner, Miller, & Libben, 2017), depression and dementia (Hart et al., 1987), multiple sclerosis (Costa, DeLuca, Costanza, & Chiaravalloti, 2019; Radomski et al., 2015), and elderly adults with dementia (Campo, Morales, & Martinez-Costillo, 2003). Moreover, scores on the SRT CLTR subscale have been shown to be the most effective at differentiating mild dementia from normal aging (Masur et al., 1989; Salmon et al., 2015). Further, the SRT has been considered a more challenging test of memory given the unrelated words in the list that do not contain categorical cues (Loring & Papanicolau, 1987). The SRT has demonstrated greater sensitivity in detecting mild memory impairments compared to other tests of memory (Leitner et al., 2017).

Psychometric evaluation of the SRT is somewhat lagging compared to other verbal memory tests, such as the CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) or the Weschler Memory Scale – Fourth Edition (WMS-IV; Wechsler, 2009). This may, in part, be due to its decline in utilization by neuropsychologists. Rabin et al. (2005) reported that the SRT was among the top 15 verbal memory tests used by neuropsychologists in North America but fell from this list in an updated survey by Rabin et al. (2016); however, various studies have been reported previously, and more recently, as noted above, that argue that it is a very good measure of verbal learning and memory from both a research and clinical standpoint. Test-retest reliability has been reported by Masur et al. (1989) for select SRT scores, such as List Total ($r = .89$) and CLTR ($r = .92$). Salinsky (2001) reported correlations for 12- to 16-week test-retest to range from .55 (30-min delay) to .71 (CLTR) in healthy individuals. The SRT has been shown to have modest correlations with the WMS and RAVLT in patients with suspected cerebral dysfunction (Macartney-Filgate & Vriezen, 1988). As well, the SRT has been validated and normed in a Greek population (Zalonis et al., 2009), a Flemish population (Thielen et al., 2019), an elderly Mexican population (Mokri et al., 2013), a Spanish population (Campo & Morales, 2004), and in American populations (Larrabee et al., 1988; Ruff et al. in 1989).

The advantages of using the SRT over other measures of memory include emerging research that it is more sensitive than the CVLT-II in detecting memory impairments (Campbell et al., 2017; Costa et al., 2019; Leitner et al., 2017; Salmon et al., 2015) and that it is a freely available, easy to administer, test. The aim of the current study was to provide an updated investigation of the SRT on inpatients during early stages of stroke recovery, examine within and between group correlations on individual test scores, and examine which, if any, test scores best discriminate between healthy individuals and inpatients after stroke.

Method

Participants

Participants who incurred a stroke (clinical group; *N* = 114) were recruited from a tertiary-care hospital, during their neuropsychological evaluation. Presence of stroke was confirmed via neuroimaging (i.e., CT Scan or MRI) upon admission to hospital for stroke-related symptoms. Following recovery, patients were transferred to the Rehabilitation Unit if they were deemed by a clinical team to be capable of benefiting from intense, inpatient rehabilitation. Eligibility for participation in the stroke group included: (1) presence of a stroke upon admission to hospital, (2) age between 18 and 90 years old at the time of neuropsychological evaluation, (3) completion of a neuropsychological battery, including the SRT, (4) and the absence of prior learning disability, previous neurological impairment (e.g., multiple sclerosis), and/or psychiatric illness. Forty-nine participants were excluded from the study, based on the above criteria. After exclusion, 65 patients (40 males and 25 females) were included in analyses. Forty-nine (75.4%) patients had incurred a right-hemisphere stroke and 16 (24.6%) incurred a left-hemisphere stroke. Ischemic stroke occurred in 48 (74%) patients, and hemorrhagic stroke occurred in 16 (25%) patients, and one (1.2%) was undetermined cause. Most patients were right-handed (*n* = 58). The average time from admission to assessment was 8.9 days (*SD* = 6.5, range = 1 – 32 days). The average age of patients was 69.4 years (*SD* = 10.8), and their average years of education completed was 12.7 (*SD* = 1.5).

Sixty-five individuals were recruited for a healthy control group via solicitation in the community and from relatives and friends of the patients included in the stroke group. Females comprised 71% of the control group (*n* = 46). The average age of participants was 69.7 (*SD* = 4.3), and average years of education was 13.3 (*SD* = 1.8). Group characteristics are displayed in Table 1.

Table 1. Demographics and SRT Z-scores of healthy control group (n = 65) and stroke sample (n = 65).

Variable	Control (n = 65)	Stroke (n = 65)		
		Stroke Sample	Left (n = 16)	Right (n = 49)
Age (M (SD))	69.71 (4.31)	69.40 (10.80)	68.06 (12.10)	69.86 (10.48)
Gender (M:F)	19:46	40:25	11:5	29:20
Education (Yrs)	13.29 (1.79)	12.70 (1.50)	13.06 (1.48)	12.53 (1.53)
Days since injury	--	8.94 (6.54)	8.53 (4.87)	9.06 (7.04)
SRT Z-Scores	M (SD)			
Total Recall	-0.47 (1.12)	-2.17 (1.34)	-2.48 (1.29)	-2.07 (1.36)
LTS	-0.22 (1.14)	-1.99 (1.52)	-2.56 (1.58)	-1.81 (1.47)
CLTR	-0.61 (0.88)	-1.76 (1.05)	-2.01 (1.08)	-1.67 (1.05)
RLTR	0.78 (1.07)	0.33 (1.29)	0.06 (1.31)	0.42 (1.28)
STR	0.12 (1.12)	1.47 (1.43)	2.02 1.65)	1.29 (1.31)
SDCR	-0.03 (0.96)	-1.37 (1.46)	-1.70 (1.39)	-1.26 (1.48)
SDMC	-0.05 (0.82)	-1.80 (1.90)	-2.49 (1.74)	-1.60 (1.91)
LDFR	-0.02 (0.98)	-1.67 (1.52)	-2.46 (1.49)	1.41 (1.45)

Note. SRT = Buschke Selective Reminding Test. Total Recall = Total List on Trial 1 to 12; STR = Short-Term Recall; LTS = Long Term Storage; CLTR = Continuous Long-Term Retrieval; RLTR = Random Long-Term Retrieval; CR = Cued Recall; MC = Multiple Choice; LDFR = Long-Delay Free Recall.

Procedure

Ethical approval for the current study was obtained from the Harmonized Research Ethics Board of the University of British Columbia Okanagan and Interior Health Authority. Data was collected from September 2013 to January 2017. Participants in the clinical group were recruited during their neuropsychological evaluation, a standard procedure for newly admitted patients on the Rehabilitation Unit. All participants were administered a comprehensive battery of tests, including the SRT, as part of a neuropsychological evaluation. In the clinical group, testing was conducted over two sessions, if necessary; whereas, testing that included the SRT was completed in one session with the control group. Raw scores from the SRT were standardized using normative data from Larrabee et al. (1988).

Statistical Analyses

Preliminary statistical analyses were conducted between age and education across groups using analysis of variance (ANOVA). Mean standardized scores were compared between the two groups. Correlation analyses of standardized scores were conducted within each group. Logistic regression analysis was employed to investigate the classification accuracy of SRT scores between groups, and a follow-up ROC curve analysis was conducted to investigate the discriminative power of the model.

Results

Preliminary Analyses

A power analysis was conducted to determine sample size estimation for the logistic regression. The following parameters were entered to determine our required sample size: two-tail design, odds ratio = 2.0, probability = 0.5, α = .05, power = .80, and R^2 of covariates = .30. The projected sample size needed was 116 participants; thus, our total sample of 130 was adequate given the estimated parameters.

Testing for assumptions was conducted prior to subsequent analyses. Regarding demographics for the stroke and control groups, a Shapiro-Wilk test revealed a violation of normality for education in the control group and for age and education in the group of patients with stroke (all *p* values < .05). A Chi-Square test revealed a significant association between sex and group, χ^2 (1) = 12.74, *p* < .001, with more males in the clinical group (*n* = 35) and more females in the control group (*n* = 46). A Mann-Whitney U test revealed no differences on SRT scores between males and females in either group (all *p* values > .05). A Mann-Whitney U test revealed no difference in age between healthy individuals (*Mdn* = 70) and patients with stroke (*Mdn* = 69), *U* = 2066.5, *z* = -0.06, *p* = .95; As well, no difference was found for education between healthy individuals (*Mdn* = 13) and patients with stroke (*Mdn* = 12), after Bonferroni-correction was applied, *U* = 1633.0, *z* = -2.16, *p* = .03.

Correlation Analyses

Spearman's rho correlation analyses of demographics and test scores were computed for each group. Results are displayed in Tables 2 and 3, respectively. In the control group, correlations ranged from -.05 (RLTR and LDFR scores) to -.96 (Total Recall and CLTR scores). Moreover, a high degree of multicollinearity was found between Total Recall, LTS, and CLTR scores (*r* = .85 to .96). Age was significantly correlated with RLTR scores (*r* = -.40). Education was significantly correlated with Total Recall scores (*r* = .19), CLTR (*r* = .26), SDCR (*r* = .36), and LDFR (*r* = .36). A point-biserial correlation revealed no significant correlations between sex and SRT scores.

Table 2. Spearman's rho correlation of Selective Reminding Test scores for healthy controls (n = 65).

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Total Recall	–										
2. STR	-.85**	–									
3. LTS	.93**	-.96**	–								
4. CLTR	.96**	-.79**	.87**	–							
5. RLTR	-.11	-.13	.07	-.28	–						
6. SDCR	.51**	-.48**	.51**	.46**	.11	–					
7. SDMC	.13	-.02	.07	.14	-.29*	.42**	–				
8. LDFR	.74**	-.63**	.68**	.74**	-.05	.52**	.14	--			
9. Age	.02	.03	.01	.03	-.40**	.02	.54**	-.05	--		
10. Sex	.11	.06	-.02	.06	.16	.13	-.04	.14	-.17	--	
11. Education	.19	-.22	.19	.26*	-.07	.36**	.24	.36**	-.06	-.10	--

Note. * *p* < .05, ** *p* < .001. Total Recall = score from Trials 1-12; STR = short-term retrieval; LTS = long-term storage; CLTR = continuous long-term retrieval; RLTR = random long-term retrieval; SDCR = short-delay cued recall; SDMC = short-delay multiple-choice; LDFR = long-delay free recall.

Table 3. Spearman's rho correlation of Selective Reminding Test scores for stroke sample (n = 65).

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Total Recall	–											
2. STR	-.69**	–										
3. LTS	.89**	-.89**	–									
4. CLTR	.87**	-.72**	.79**	–								
5. RLTR	.31*	-.44**	.51**	.08	–							
6. SDCR	.56**	-.46**	.58**	.45**	.35**	–						
7. SDMC	.34*	-.36*	.36*	.29*	.24	.42**	–					
8. LDFR	.78**	-.76**	.83**	.70**	.37**	.64**	.48**	--				
9. Age	.43**	-.36**	.38*	.58**	-.27*	.11	.05	.30	--			
10. Sex	.03	.04	.05	-.04	.04	-.04	-.15	.03	.22	--		
11. Educ	.00	-.13	.05	.03	.08	0.6	.04	.09	.10	-.23	--	
12. Admit-Test[a]	-.07	-.03	-.11	-.03	-.08	-.19	.01	-.16	.11	.01	.09	--

Note. * $p < .05$, ** $p < .001$. Total Recall = score from Trials 1-12; STR = short-term retrieval; LTS = long-term storage; CLTR = continuous long-term retrieval; RLTR = random long-term retrieval; SDCR = short-delay cued recall; SDMC = short-delay multiple-choice; LDFR = long-delay free recall.
[a]Admit-Test: only patients with stroke used in analysis (*n* = 65)

In the clinical group, there was also indication of multicollinearity between Total Recall, LTS, and CLTR (r = .79 to .89). All scores were significantly correlated at the $p < .05$ level, the vast majority significant at the $p < .001$ level. Age was significantly correlated with Total Recall, STR, LTS, CLTR, and RLTR (r = -.27 to .58). Education was not significantly correlated with test scores (r = .00 to -.23). A point-biserial correlation analysis revealed no significant correlation between sex and scores (r = .05 to .16) for the clinical group (r = -.04 to .05). For the clinical group, no significant association was found between time since injury (days) and SRT scores (all p values > .05).

Table 4. Logistic Regression Predicting Likelihood of Stroke Based on SRT Z-Scores.

	B	SE	Wald	*df*	OR	95% CI for OR	
						Lower	Upper
STR	-0.64	.44	2.17	1	1.90	0.81	4.46
CLTR	-1.37	.62	4.95*	1	3.94	1.18	13.16
RLTR	-0.55	.34	2.63	1	1.73	0.89	3.33
SDCR	-0.30	.25	1.43	1	1.34	0.83	2.19
LDFR	-0.46	.32	2.05	1	1.57	0.85	2.94

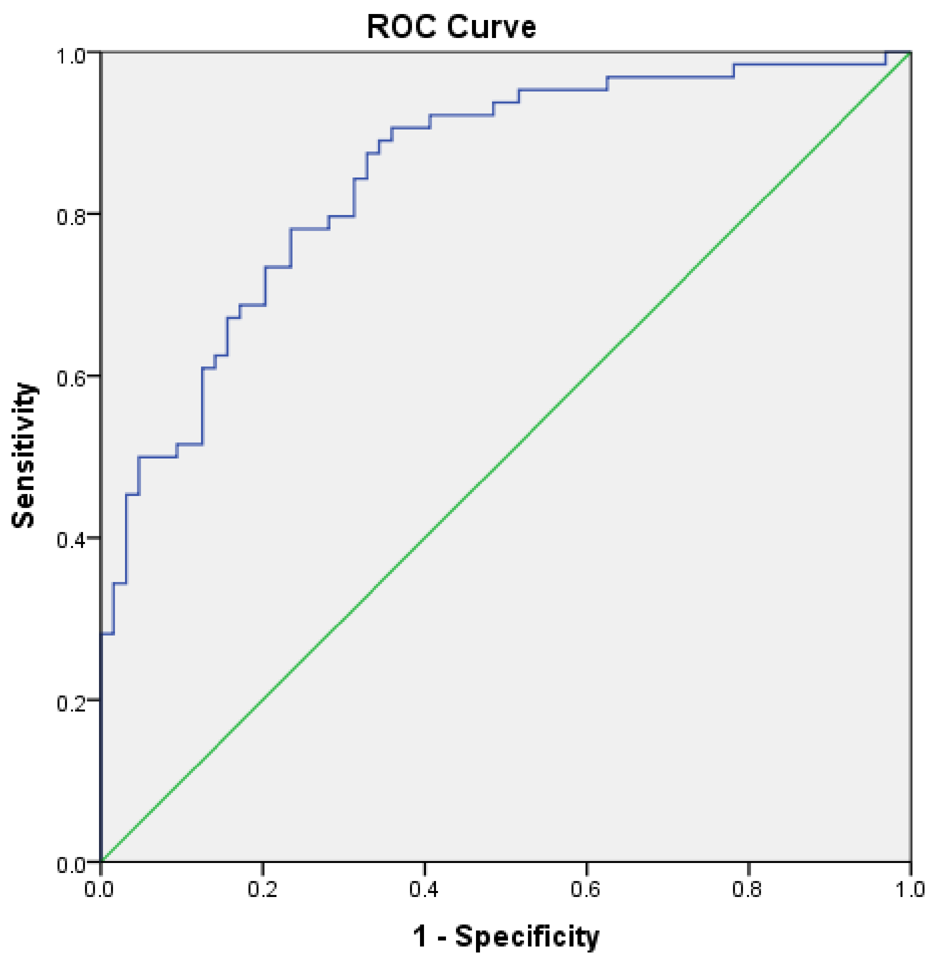
* $p < .05$. Model Summary: $\chi^2(5) = 53.98$, $p < .001$, $R^2 = .46$.
SRT = Buschke Selective Reminding Test; STR = Short-Term Retrieval; CLTR = Continuous Long-Term Retrieval; RLTR = Random Long-Term Retrieval; SDCR = Short-Delay Cued-Recall; LDFR = Long-Delay Free Recall; OR = Odds Ratio.

Group Comparison of Scores on the SRT

Generally, Z scores were higher on indices depicting better performance (i.e., Total, LTS, CLTR, SDCR, SDMC, and LDFR), and lower on indices depicting worse performance (i.e., STR) for right hemisphere strokes (compared to left hemisphere). Standardized scores on the SRT for all groups are presented in Table 1. Within the clinical group, interhemispheric comparisons on test scores were investigated. After adjusting the critical value (.05 / 8 = .006), no significant differences were found between patients with left and right hemisphere strokes on SRT scores (all p values > .006). Thus, we chose to collapse patients in the left and right hemisphere groups for subsequent analyses to show the overall clinical utility of the SRT in an acute stroke sample.

Criterion Validity of the SRT

A binomial logistic regression was computed to ascertain SRT performance on the likelihood that participants had a stroke. Prior to analyses, assumptions were checked: The Box-Tidwell procedure revealed all independent variables (IVs) to be linearly related to the logit of the dependent variable (DV) (all *p* values > .05); given the results of the Spearman Rho's correlation analysis, we chose to remove LTS and Total Recall due to the high degree of multi-collinearity with CLTR; the model consisted of STR, CLTR, RLTR, SDCR, and LDFR scores. The results of the logistic regression were statistically significant, $\chi^2(5) = 53.98$, $p < .001$. The model explained 46% of the variance in stroke prediction and correctly classified 76% of the cases. Sensitivity was 72% and positive predictive value was 78%; specificity was 80% and negative predictive value was 74%. Only scores on CLTR were statistically significant in the model (OR = 3.94); decreasing CLTR scores were associated with an increased likelihood of presenting with stroke-related verbal learning deficits. The area under the ROC curve was .85 (95% CI, .78 to .91), indicating an excellent level of discrimination (Hosmer et al., 2013) between the clinical and control groups (see Figure 1).



I ROC Curve of SRT Predictive Model (STR, CLTR, RLTR, SDCR, and LDFR scores) Discriminating Between Patients with Stroke and Healthy Controls; AUC = Area Under the Curve (.850, 95% CI [.78, .91], $p < .001$). These results suggest 'excellent' discriminative power of the model (Hosmer et al., 2013).

Discussion

The aim of the current study was to determine the clinical utility of the SRT in differentiating between patients with stroke and healthy individuals. Current results provide empirical evidence for validity of the SRT and much needed updating to the test's psychometric evaluation in the literature. We compared performance on standardized scores of the SRT between healthy, community-dwelling, individuals and inpatients engaged in acute rehabilitation following a stroke. We also examined the correlation among SRT scores within each group. Scores were effective at discriminating between patients with stroke and healthy controls, based on their sensitivity, specificity, positive- and negative-predictive power. Specifically, scores on CLTR have excellent discriminate power between these two populations. As well, there appeared to be a high degree of multicollinearity among some SRT scores that was reflected in both groups. In essence, these findings are in line with the well-established body of literature that verbal learning and memory impairments are common after stroke (American Stroke Association, 2013; Lezak et al., 2012) and extend research in this area by validating the psychometric properties of the SRT in a stroke population with the identification of the most clinically useful scores relevant to assessing patients.

First, we found that patients who had suffered a stroke scored significantly lower on all selected SRT scores (or higher on scores that would indicate greater impairment) as compared to a healthy control group. Correct classification rate was 76%; with acceptable sensitivity (72%), PPV (78%), specificity (80%), and NPV (74%). The model provided excellent discrimination between the two groups based on ROC analysis (AUC = .85 (95% CI [.78 to 91]; Hosmer et al., 2013). Moreover, the CLTR scale may be the most effective at discriminating between patients with stroke and healthy controls. Current findings support previous studies that have demonstrated the discriminant value of SRT scores between healthy controls from patients with multiple sclerosis (Radomski et al., 2015) and elderly adults with dementia (Campo et al., 2003), as well as mild dementia from normal aging (Masur et al., 1989). To the best of our knowledge this is the first study to investigate the criterion validity of the SRT by comparing an inpatient stroke sample to healthy controls.

The results of within-group correlation analyses of SRT scores suggest that the multicollinearity we found in the control group was also present in the patients with stroke group. These scores may represent and tap a similar construct of memory within the test. These results should be explored further and in other populations.

Limitations to the current study should also be addressed. First, the patient group represents a convenience sample that was recruited after having been admitted to the inpatient rehabilitation unit following a stroke. Results may not translate to patients who were not deemed eligible for acute inpatient rehabilitation or those who are further in their recovery (e.g., outpatients). Moreover, patients with left hemisphere stroke were underrepresented due to the greater likelihood of language disturbance occurring in this subgroup and excluding participation in the study. We did not include a measure of stroke severity or volumetric data from brain imaging, that would have allowed us to further explore the interhemispheric differences, or lack thereof, on SRT scores. As well, we found no sex differences between any scores for patients with stroke or healthy controls. This contrasts with the reported differences between males and females on tests of verbal recall. However, this may be a result of the correction made for males on the SRT when computing scores; it would appear the correction is successful in minimizing sex differences.

The current findings are beneficial for three reasons: (1) they provide updated results on the validity of the SRT for inpatients with stroke in a rehabilitation setting, and (2) provide evidence that there may be some redundancy of test scores, specifically, LTS, Total List, and CLTR, and (3) suggest that scores on CLTR may be the most beneficial at identifying memory impairment in patients after a stroke. We identified a general trend for poorer performance following a left hemisphere stroke compared to right hemisphere stroke, a finding consistent with reports of interhemispheric differences on verbal learning and memory following insult to the brain (Lezak et al., 2012). Moreover, our results suggest that long-delay free recall may be the most effective at discriminating between those two stroke subgroups.

Based on current findings, the SRT is a valid measure of memory impairment for patients in the weeks following a stroke. Given the high frequency of reported memory impairment in patients after a stroke, it is important that tests purported to assess memory be scrutinized in their ability to detect and evaluate impairment. Moreover, it should be echoed that this process is always ongoing and never finalized; that is, replication of these evaluations should be undertaken periodically to ensure that the test remains suited to the population, setting, and context of the evaluation.

Future studies should consider including measures of daily function and activity that can evaluate the ecological validity of the SRT and compare to other measures purporting to measure verbal learning and memory. As well, the multicollinearity that was presented between test scores suggest future studies with larger sample sizes and differing populations may investigate methods for a more parsimonious scoring/interpretation process.

Conclusion

In conclusion, current results provide empirical evidence for validity of the SRT and much needed updating to the test's psychometric evaluation in the literature. SRT scores were effective at discriminating between patients with stroke and healthy controls, based on their sensitivity, specificity, positive- and negative-predictive power. Overall, results from the current study validate the psychometric properties of the SRT in a stroke population with the identification of the most clinically useful scores relevant to assessing patients.

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