Effect of Left Hemisphere Damage on Verbal and Visual Short Term Memory
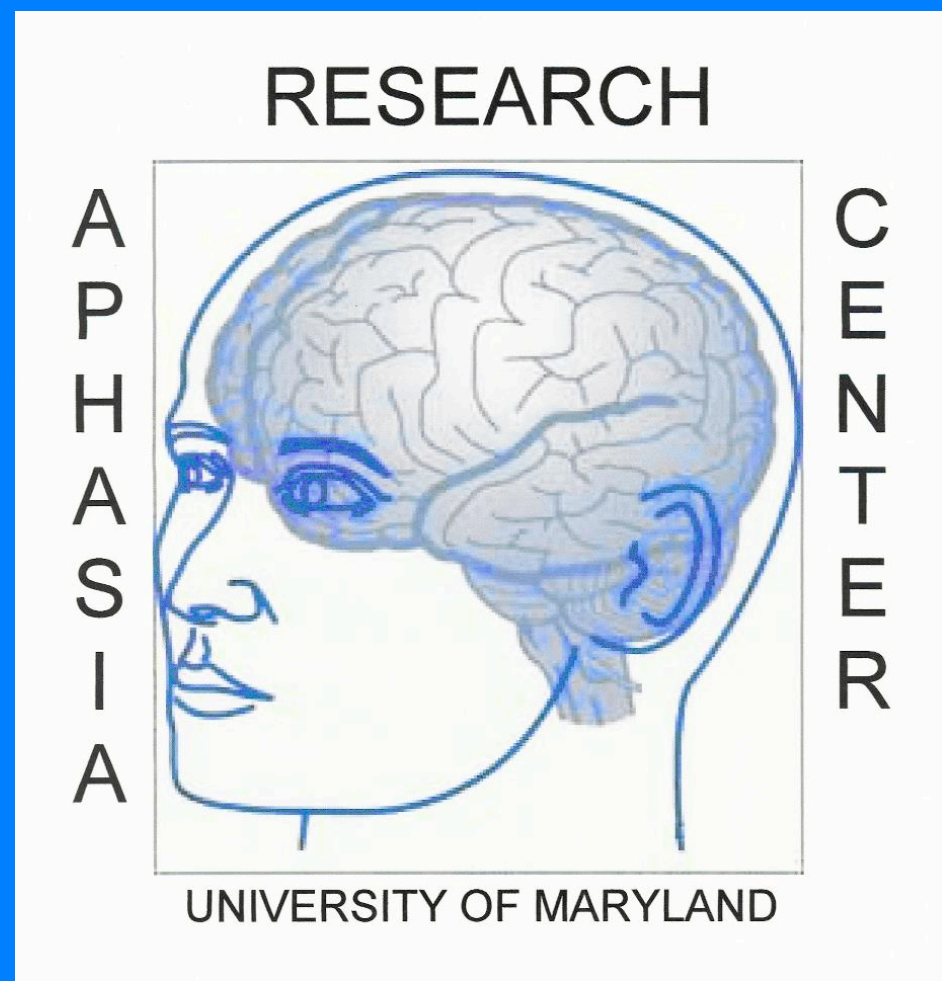
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ABSTRACT/INTRODUCTION

Individuals with left hemisphere damage, such as from a stroke, experience difficulty in speaking, a condition called aphasia. Testing short-term memory (STM) in these individuals is complicated by their verbal deficit because most memory tests require participants to verbally repeat digits or words. This study examined the pattern of verbal and spatial STM performance in aphasia as well as the impact of a nonverbal response mode such as pointing. Specifically, this study sought to investigate three questions:

1. Does left hemisphere damage impact both verbal (Digit Forward and Digit Pointing span) and visual (Picture Pointing and Spatial Pointing span) STM?
2. Is there a difference in verbal STM (digit and picture span tasks) scores with oral versus pointing responses?
3. How does STM performance relate to the profile of language impairment in aphasia, especially for comprehension, repetition, and word finding?

METHODS

- Forty-five adults who developed aphasia as a result of single left hemisphere cerebrovascular accident participated in the study.
- A retrospective analysis was conducted on the relationship between STM and language in persons with aphasia (PWA). Recorded STM task scores using the DeRenzi and Nichelli STM tasks (DeRenzi & Nichelli,1975) and recorded language task scores using the Western Aphasia Battery-Revised (WAB-R) (Kertesz, 2006) were analyzed.
- Twelve age-matched, gender-matched, and education-matched neurologically healthy adult participants participated and provided control STM data.
- Data was empirically collected on STM tasks using the DeRenzi and Nichelli short term memory tasks (DeRenzi & Nichelli,1975).
- ANOVA tests, and independent and repeated measures t-tests were used to assess if there were significant score differences between the WAB-R and STM tasks and for significant score differences of the same task between healthy controls and PWA.
- Multiple regression analyses were used to assess if any WAB-R or STM task could significantly predict scores of other tasks.

RESULTS-1.

Figure 1.
Comparison of STM Tasks Within PWA and Healthy Adult Groups

Table 1.
Scores of STM Tasks Within PWA and Healthy Adult Groups

Task	Neurologically Healthy		Aphasia		Statistics, Mann Whitney U, p
	Mean (SD)	Range	Mean (SD)	Range	
Digit Forward	8.36 (1.47)	6 to 10.5	4.29 (2.43)	0 to 9	$U=452$, $p<.001$
Digit Pointing	8.16 (1.64)	6 to 10.5	3.83 (2.28)	0 to 8	$U=484$, $p<.001$
Picture Pointing	5.75 (1.30)	4 to 9	2.88 (1.79)	0 to 6.5	$U=463$, $p<.001$
Spatial Pointing	6.16 (1.40)	4 to 10.5	5.18 (1.91)	0 to 8.5	$U=328$, $p=.15$

Note. * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates a $p<0.001$. The four STM tasks include Digit Forward (verbal instructions, verbal response), Digit Pointing (verbal instructions, non-verbal response), Picture Pointing (verbal instructions, non-verbal response), and Spatial Pointing (non-verbal instructions, non-verbal response)

RESULTS-2.

Table 2.
Regression Analysis of STM Tasks in Healthy Controls and PWA

	Digit Forward	Digit Pointing	Picture Pointing	Spatial Pointing
Neurologically healthy STM				
Model (F, p, R^2)	$F(3,11) = 8.59$, $p = .007$, $R^2 = .76$	$F(3,11) = 8.94$, $p = .006$, $R^2 = .77$	$F(3,11) = 6.09$, $p = .018$, $R^2 = .70$	$F(3,11) = 3.45$, $p = .072$, $R^2 = .56$
Digit F		0.76**	0.18	0.03
Digit P	0.78**		0.32	-0.39
Picture P	0.14	0.24		0.88*
Spatial P	0.01	-0.21	0.61*	
Aphasia STM				
Model (F, R^2)	$F(3,31) = 12.03$, $p < .001$, $R^2 = .54$	$F(3,31) = 13.11$, $p < .001$, $R^2 = .56$	$F(3,31) = 7.34$, $p = .001$, $R^2 = .41$	$F(3,31) = 3.79$, $p = .02$, $R^2 = .27$
Digit F		0.61***	0.26	-0.18
Digit P	0.64***		0.20	0.22
Picture P	0.21	0.15		0.47*
Spatial P	-0.11	0.13	0.38*	

Note. * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates a $p<0.001$. Significant models and predictors are bolded in purple.

RESULTS-3.

Table 3.
Regression Analysis of PWA WAB-R Scores on STM Tasks

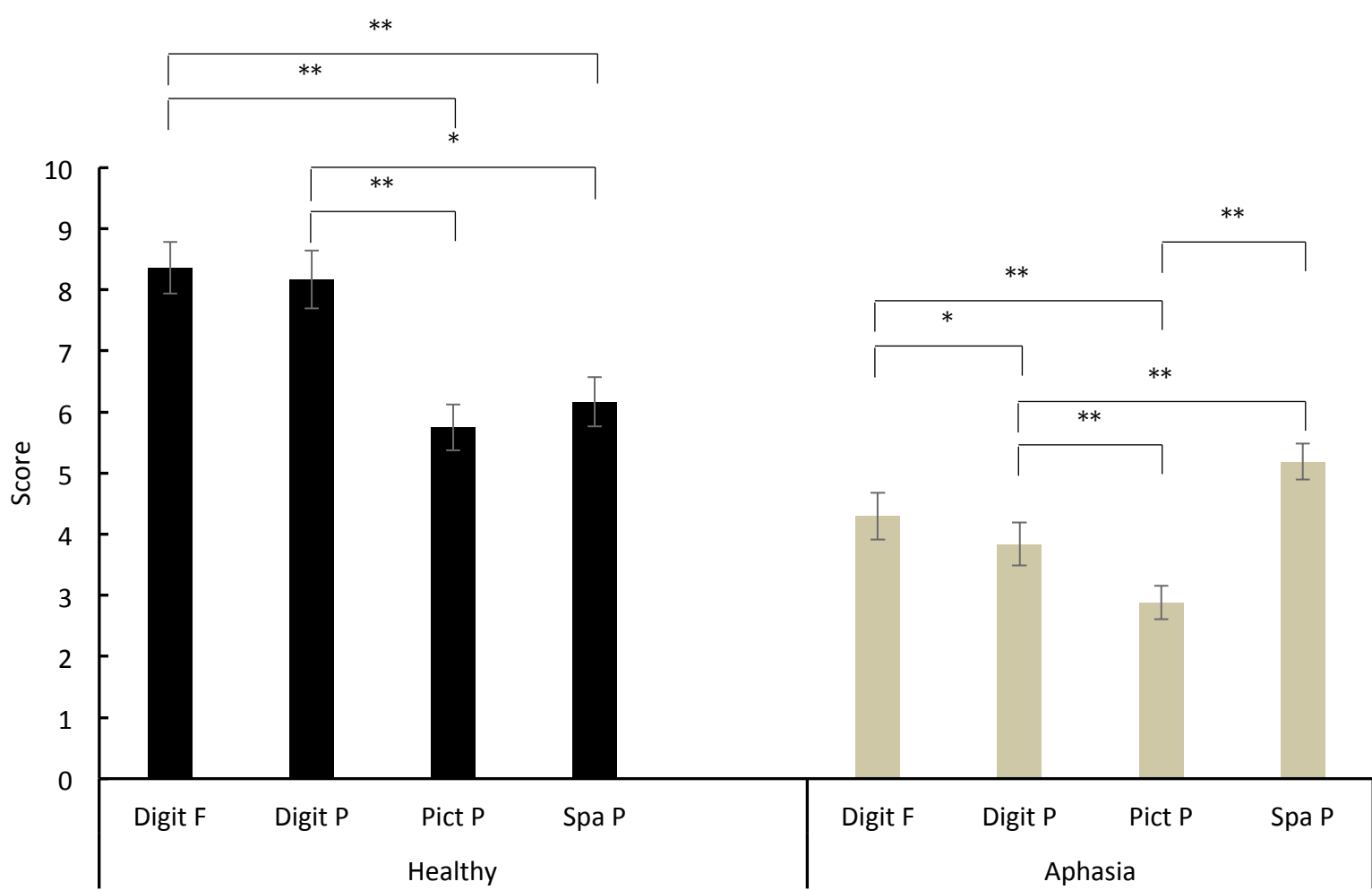|	Model (F, p, adjusted R^2)	Digit Forward β,r	Digit Pointing β,r	Picture Pointing β,r	Spatial Pointing β,r
Yes/No Questions	$F(4,30)=3.42$, $p=.02$, $R^2 = .22$	0.26, 0.49**	0.22, 0.53**	0.24, 0.52**	-0.15, 0.32*
Auditory Word Recognition	$F(4,30)=6.44$, $p=.001$, $R^2 = .39$	0.29, 0.64**	0.27, 0.68**	0.31, 0.63**	-0.18, 0.34*
Sequential Commands	$F(4,30)=10.70$, $p< .001$, $R^2 = .53$	0.46*, 0.57**	-0.07, 0.61**	0.47**, 0.74**	0.04, 0.44**
Repetition	$F(4,30)=16.60$, $p< .001$, $R^2 = .65$	0.64***, 0.81**	0.16, 0.59**	0.19, 0.48**	-0.33**, 0.14
Object Naming	$F(4,30)=4.94$, $p=.004$, $R^2 = .32$	0.55*, 0.54**	-0.05, 0.47**	0.16, 0.49**	0.05, 0.26
Word Fluency	$F(4,30)=5.44$, $p=.002$, $R^2 = .34$	0.05, 0.41**	0.23, 0.58**	0.44*, 0.67**	0.04, 0.50**
Sentence Completion	$F(4,30)=13.29$, $p< .001$, $R^2 = .59$	0.70***, 0.64**	-0.22, 0.42**	0.34*, 0.66**	0.09, 0.32*
Responsive Speech	$F(4,30)=8.35$, $p< .001$, $R^2 = .46$	0.46*, 0.54**	-0.01, 0.58**	0.29, 0.61**	0.17, 0.36*
Aphasia Quotient	$F(4,30)=18.07$, $p< .001$, $R^2 = .67$	0.49**, 0.75**	0.31*, 0.72**	0.21, 0.62**	-0.11, 0.35*

Note. * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates a $p<0.001$. r = adjusted R^2 from a Spearman's Rho analysis. β indicates the standardized beta coefficient of the variable. Significant models and predictors are bolded in purple.

Conclusions

Analysis of STM performance from 45 persons with a diagnosis of aphasia after a left hemisphere stroke and 12 age-matched healthy adults showed that persons with aphasia are impaired in all verbal STM tasks (digit and picture span tasks) irrespective of whether they used speech or pointing to indicate their responses. In contrast, spatial STM (spatial pointing span) was preserved (Fig.1, Table 1). Digit Forward and Digit Pointing (numerical memory) tasks significantly predicted each other, and Picture pointing (image memory) and Spatial memory (spatial memory) significantly predicted each other in both healthy control and PWA groups (Table 2) and indicate possible shared processing mechanisms for those task pairs. Furthermore, STM scores significantly predicted language impairment in aphasia on all tested WAB-R tasks (Table 3). These findings indicate in the interpretation of WAB-R tasks as a diagnostic tool in aphasia must take into account STM impairment.

References: De Renzi, E. & Nichelli, P. (1975). Verbal and nonverbal short-term memory impairment following hemispheric damage. *Cortex*, *11*(4), 341-354. doi: 10.1016S0010-9452(75)80026-8   Kertesz, A. (2006). *Western Aphasia Battery-Revised*. San Antonio, TX: Pearson.