Evidence for contemporary theories on the organization and structure of semantic knowledge has been based primarily on findings with aphasic patients (Caramazza and Hillis, 1995; Shelton and Caramazza, 1999; Bird, Howard and Franklin, 2001; Shapiro and Caramazza, 2001). Research specific to word retrieval of nouns and verbs suggest that performance levels and error types relate to a neuroanatomic region of compromise, modality-specific subcomponents, categorical deficits, or production difficulties.

Most individuals studied have been aphasic adults following stroke with defined lesions; lesion location has assisted in developing theories related to the representation of semantic knowledge and lexical access. Populations that do not exhibit defined lesions, such as mild traumatic brain injury (MTBI), may be differentially affected relative to lexical access during naming tasks, particularly relative to neuroanatomical theories. MTBI is a "traumatically induced physiological disruption of brain function manifested by at least one of several criteria" (p.852), including loss of consciousness < 30 minutes, post-traumatic amnesia < 24 hours, alteration in mental state and focal neurological deficits. Glasgow Coma Scale (GCS) (Jennett & Teasdale, 1974) score must be 13-15 by thirty minutes after injury (Paniak et al, 1998).

Word retrieval deficits in confrontational naming tasks have been identified following MTBI (King, Hough, Walker, Rastatter, and Holbert, 2004; Barrow, Rastatter, Hough, Walker, Rotundo, and Holbert, 2003). This population does not lend itself to the established neuroanatomical explanations of noun-verb production difficulties. After MTBI, persons do not exhibit circumscribed, focal lesions but have a diffuse pattern of brain damage.

A double dissociation for nouns and verbs has been observed in aphasic patients, suggesting the existence of separable grammatical word class sub-processors within the lexical system (Gomes et al., 1997). With double dissociation, the question arises as to whether the difficulty arises at the level of central semantic organization of the lexicon or is a result of disturbance that affects lexical processing at the output level. Two theories have developed to explain the occurrence of a double dissociation: semantic-categorical, having a semantic representation in the brain, and grammatical-categorical, having a syntactical representation. Caramazza and Shelton (1998) proposed a sensory/functional theory to account for differences in the ability to name living and nonliving things. Bird et al.'s (2000) extension of this theory suggests that retrieval is based upon identification of sensory features. They discussed how a sensory feature deficit within the semantic system or a disconnection between features and output could account for both noun and verb naming deficits, proposing that this model considers both the semantic and grammatical category deficits. Shapiro and Caramazza (2001) indicated this extended version is an oversimplification; yet, Bird et al. (2001) suggested that their theory supports findings that nouns are easier to access than verbs, as nouns have more sensory features than verbs and proposed that the extended version explains grammatical category specific deficits. The proposed alternative is that there is no single account adequate to explain both noun and verb dissociations.

The noun-verb double dissociation has led researchers to suggest different neural networks for processing nouns and verbs. The noun network has been linked to posterior regions of the brain within the visual-object processing regions, while the verb network is linked to frontal regions within the motor-processing area. Studies on the neural representation of nouns and verbs in normal participants suggest that noun and verb meanings are actually represented within an undifferentiated cortical network which is not divided by category or domain; anatomically separate mental lexicons cannot be distinguished (Tyler, Russell, Fadili, and Moss, 2001; Soros, Carnelissen, Laine, and Salmelin, 2003). As differences have been observed

primarily with aphasic participants, evidence for differences in activation may emerge only after disruption of the normal language network.

Research has indicated that TBI results in diffuse damage to frontal and temporal lobes with concomitant dysfunction in memory, learning, and higher cognitive processes such as abstraction and reasoning skills (Lezak, 1983, 1995, 2004). The diffuse nature of MTBI may expand findings from lesion studies by providing a different perspective on the causal relationship of noun and verb categorization deficits. Although some research has indicated that word retrieval deficits occur with MTBI, this has been minimally addressed, especially as it relates to semantic or grammatical categorization of lexicon. Furthermore, MTBI has not been studied in relation to lexical processing of nouns and verbs.

The purpose of this study was to investigate possible dissociation between noun and verb retrieval following MTBI using the Test of Adolescent Adult Word Finding (TAWF) (German, 1990). Naming accuracy and response time for pictured nouns and verbs was examined.

Method

Two groups, 10 MTBI and 10 controls, participated (Tables 1, 2). TBI participants met the established criteria for MTBI classification as indicated previously and had scores > 25 on the Raven's Coloured Progressive Matrices (RCPM) (Ravens, 1956). Participant age range was 18-45. The control group was age, gender, and education matched.

Pre-experimental tasks included the Peabody Picture Vocabulary Test-III (PPVT-III) (Dunn & Dunn, 1997) (score $\geq$ 85) and the Scales of Cognitive Ability for Traumatic Brain Injury (SCATBI) (Adamovich & Henderson, 1992) (TBI only). The TAWF was the experimental task used specifically to look at picture naming of nouns versus verbs. The TAWF was computerized using SuperLab Pro with copyright permission of the author and publisher.

Data was examined relative to accuracy and response time in noun and verb naming, within and between groups, and the relationship between receptive vocabulary (PPVT-III) and naming accuracy.

Results

Two-sample t-tests revealed that the MTBI group was significantly slower and less accurate (Graphs1, 2) than the non-brain damaged (NBD) group for nouns ($t=85.324$; $p<.0001$; $t=3.068$; $p<.009$) and verbs ($t=165.912$; $p<.0001$; $t=1.872$; $p=.05$), respectively (Tables 3, 4, 5, 6). Wilcoxon paired sample t-tests revealed that there were no significant differences in accuracy or response time of naming nouns versus verbs for the MTBI or the NBD group ($p > .05$). Pearson-Product Moment Correlations revealed no significant relationships between noun or verb naming and receptive vocabulary for either group ($p> .05$)

Discussion

Previous studies have focused on either lesioned or NBD populations to look at noun-verb naming differences and have proposed that defined pathways and neuroanatomic regions of function are evident. Most recently, research has indicated that processing of nouns and verbs is more complex and most probably represented in a more distributed cortical network than originally considered. The current results support the idea of a more complex and distributed network. MTBI is recognized as a group experiencing a diffuse injury. The participants in this study did not exhibit any defined lesions (negative CT scans); the similar performance for nouns and verbs by the MTBI group is indicative of a more distributed cortical or subcortical network for noun-verb processing and retrieval.

The MTBI group demonstrated diminished accuracy as compared to the NBD group with significantly slower response time. Of note, no significant difference was noted for the MTBI or

NBD group when comparing verb to noun naming. This similar performance is in contrast to earlier studies which have indicated verb processing to be more difficult.

While much research has been conducted with lesioned populations, studying MTBI provides valuable information related to diffuse injury and the impact on function. This information also may lead to more substantiation of the cortical networks involved in processing nouns and verbs.

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TABLE 1: Participant Gender by Group

gender

group			Frequency	Percent	Valid Percent	Cumulative Percent
tbi	Valid	male	4	40.0	40.0	40.0
		female	6	60.0	60.0	100.0
		Total	10	100.0	100.0	
normal	Valid	male	4	40.0	40.0	40.0
		female	6	60.0	60.0	100.0
		Total	10	100.0	100.0	

TABLE 2: Means and Standard Deviations for Age and Education by Group

Descriptive Statistics

group		N	Minimum	Maximum	Mean	Std. Deviation
tbi	age	10	18.33	43.16	28.8130	8.13761
	education	10	12	16	13.70	1.767
	Valid N (listwise)	10				
normal	age	10	18.33	42.33	28.7970	7.89382
	education	10	12	17	14.00	1.764
	Valid N (listwise)	10				

TABLE 3: Percentage accuracy for Nouns and Verbs for the TBI Group

			accuracy		Total
			incorrect	correct	
TBI	NOUNS	Count	52	318	370
		% within subtest	14.1%	85.9%	100.0%
		% of Total	4.9%	29.7%	34.6%
	VERBS	Count	23	187	210
		% within subtest	11.0%	89.0%	100.0%
		% of Total	2.1%	17.5%	19.6%
		% of Total	12.8%	87.2%	100.0%

TABLE 4: Percentage Accuracy for Nouns and Verbs for the NBD Group

		accuracy		Total
		incorrect	correct	
NOUNS	Count	14	356	370
	% within subtest	3.8%	96.2%	100.0%
	% of Total	1.3%	33.3%	34.6%
VERBS	Count	11	199	210
	% within subtest	5.2%	94.8%	100.0%
	% of Total	1.0%	18.6%	19.6%

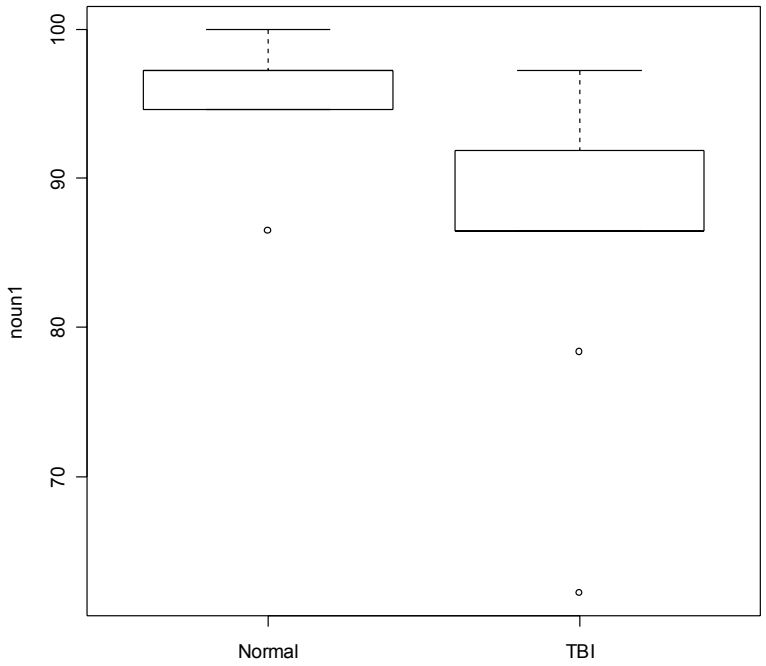
TABLE 5: MTBI Means and standard deviations for the Response Times on Nouns and Verbs

	subtest		Statistic	Std. Error
time	NOUNS	Mean	2698.26	109.098
		Std. Deviation	2098.543	
		Minimum	390	
		Maximum	11672	
	VERBS	Mean	2393.75	108.453
		Std. Deviation	1571.634	
		Minimum	311	
		Maximum	10350	

TABLE 6: NBD Means and standard deviations for the Response Times on Nouns and Verbs

	subtest		Statistic	Std. Error
time	NOUNS	Mean	1719.25	72.819
		Std. Deviation	1400.709	
		Minimum	40	
		Maximum	10000	
	VERBS	Mean	1538.16	81.236
		Std. Deviation	1177.224	
		Minimum	341	
		Maximum	10000	

GRAPH 1: Group Comparison on Accuracy with Naming Nouns



GRAPH 2: Group Comparison of Accuracy with Naming Verbs