

5-9-2015

A Pilot Study Investigating Comprehension of Driving Vocabulary in Adolescents with Language Impairment

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Recommended Citation

Pandolfe, Jessica M., "A Pilot Study Investigating Comprehension of Driving Vocabulary in Adolescents with Language Impairment" (2015). *Master's Theses*. 738.
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A Pilot Study Investigating Comprehension of Driving Vocabulary
in Adolescents with Language Impairment

Jessica Marie Pandolfe

B.A., University of Connecticut, 2013

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Arts

At the

University of Connecticut

2015

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[2015]

APPROVAL PAGE

Masters of Arts Thesis
A Pilot Study Investigating
Comprehension of Driving Vocabulary in Adolescents with
Language Impairment

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2015

Acknowledgements

I would like to extend sincere gratitude to my major and thesis advisor, Dr. Tammie Spaulding, who made completion of this research possible. I would also like to thank Dr. Carl Coehlo and Dr. Bernard Grela for their time in reviewing my work, as well as Elizabeth Zyzo for her contributions to this study. I am also sincerely appreciative of the guidance I received from all the UConn research and clinical faculty in the Department of Speech, Language, and Hearing Sciences, who each played a role in instilling in me a great enthusiasm and excitement for contributing to the unique and awe-inspiring field of speech-language pathology. Finally, I would like to thank my family and friends who continue to support me in my academic and life endeavors.

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Abstract

Purpose: The purpose of this study was to investigate if adolescents with LI are at increased risk relative to unimpaired peers at struggling to comprehend driving-related vocabulary found in driving preparation material.

Method: This study included 11 adolescents with LI and 11 adolescent controls with typical language development. Participants completed a self-developed receptive vocabulary measure, the Driving-Related Picture Vocabulary Task, which consisted of simple noun, compound noun, and simple verb driving terminology.

Results: The Driving-Related Picture Vocabulary Task was found to have strong convergent validity with the Peabody Picture Vocabulary Test—Fourth Edition (Dunn & Dunn, 2007). Strong positive correlation was also found between accuracy on the Driving-Related Picture Vocabulary Task and overall oral language skills in adolescents. The LI group understood fewer driving-related terms compared to TD peers. Adolescents with LI and TD peers were found to have similar scores on the experimental task for understanding simple nouns. However, accuracy in adolescents with LI was found to be lower and statistically significant compared to the control participants in understanding simple verbs and compound nouns, for both noun + noun and adjective + noun compounds.

Discussion: Decreased understanding of terms found in the Driver's Manual puts adolescents with LI at risk for failing to earn a driver's license, a major rite of passage for adolescents. Failure to comprehend driving terminology may also pose additional safety risks if these adolescents are unable to understand important rules, regulations, and practices for safe driving because of the challenging terminology used to describe them.

Key Words: Adolescents, compound nouns, driving, language impairment, transition planning, verbs, vocabulary

Introduction

There is a substantial body of research documenting difficulties in vocabulary acquisition for children with specific Language Impairment (LI), as well as the persistence of these difficulties into adolescence (e.g., Gray, 2003; 2006; McGregor, Oleson, Bahnsen, & Duff, 2013; Alt, Plante, & Creusere, 2004). While studies have linked the slower word learning and deficient lexicons of individuals with LI to poor performance on academic measures (e.g., Conti-Ramsden, Durkin, Simkin, & Knox, 2009; Young, Beitchman, Johnson, Douglas, Atkinson, Escobar & Wilson, 2002), research investigating the link between the poor lexical acquisition and performance on non-academic functional assessments in school-age children with LI is limited. One potential non-academic assessment in which a reduced vocabulary repertoire is likely to negatively impact performance is the learner's permit test, a multiple choice exam assessing prospective drivers' knowledge and application of rules, precautions, and decision-making skills for safe driving practices. Passing this test is a prerequisite for adolescents to participate in a major rite of passage, the right to drive. Adolescents with LI may be at an increased risk of failing the learner's permit test as a result of the appreciable amount of challenging vocabulary included in the study material, the Driver's Manual, and the learner's permit test itself. However, no research as of yet has investigated if adolescents with LI are vulnerable to failing the learner's permit test as a result of reduced vocabulary knowledge.

Neurological, Structural and Functional Changes in Adolescence

Adolescence, a developmental period characterized by the transition from childhood to adulthood, is characterized by marked cortical changes (e.g., Blakemore, 2012b; Spear, 2000; Whitford et al., 2007). Although the precise age at which

adolescence typically begins and ends continues to be debated, most concede that it begins around 12 years of age and lasts until at least 18 years of age (Spear, 2000). Magnetic Resonance Imaging studies on adolescent brains have found that the maturing frontal and parietal lobes undergo an increase in white matter and decrease in grey matter as children transition into adolescence (Blakemore, 2012b; Whitford et al., 2007); phenomena that are indicative of myelination and synaptic pruning, respectively (Whitford et al., 2007). Where synaptic pruning is the process by which unused synapses expire, myelination is a process responsible for increasing the rate at which impulses travel via frequently used neural circuits. Such processes boost the efficiency and speed of information transfer throughout the affected region. Findings suggest that frontal lobe development begins in the posterior portion and progresses toward the anterior (Gogtay et al., 2004); thus, the prefrontal cortex (PFC), with the exception of the earlier-maturing frontal pole, is later to mature than other portions of the frontal lobe (Giedd, 2004; Gogtay et al 2004). In fact, dorsolateral PFC maturation can extend as late as the early 20s.

High-level executive functioning, controlled by the frontal lobe, is enhanced with aforementioned neural changes. Specifically, planning and strategizing—functions supported by the prefrontal cortex (PFC; Giedd, 2004)—are known to improve. Maturation of the PFC into adolescence is associated with an increase in the optimality of decision-making and a reduction in impulsivity (Giedd, 2004). As the frontal lobe approximates full maturation, executive functions improve and adolescence approaches an end (Giedd, 2004). The cognitive-behavioral patterns that emerge during the adolescent period are attributed to the nature and chronology of cortical development (Blakemore, 2012a).

Driving: A privilege

Improved cognitive neural functioning in the frontal lobe, a region that is highly responsible for planning and strategizing (Giedd, 2004) is bound to influence decision-making while driving. Any driver would concur that operating a motor vehicle demands strategic and rapid responses to unpredicted events; thus, improved executive functioning that proceeds from frontal lobe changes in white and gray matter support improved abilities for responding to situations encountered on the road. Frontal lobe dysfunction, related to developmental disorder, acquired brain injury, and aging, are known to be associated with impulsivity, poor judgment, decreased self-monitoring, and other maladaptive executive behaviors, which result in unsafe driving deportment and inhibit driving privileges (Barkley & Cox, 2007; Dirkilov et al., 2015; van Zomeren, Brouwer, & Minderhoud, 1987; Wood & Rutterford, 2004). The gradual course of PFC maturation and subsequent improved executive functioning skills in adolescents make it no mystery as to why, in most states, teens cannot earn a Driver's License until they are 16 years of age. Further acknowledging the progressive maturation of executive functioning in adolescence, many states have adopted graduated driver licensing programs, requiring licensed drivers under 18 years of age to earn their full driving privileges in a piecemeal fashion (Governors Highway Safety Association, 2012); yet, alterations made to the licensing process have not deterred adolescents from taking full advantage of this privilege, as nearly 9 million adolescents in the U.S. under 20 years of age hold a Driver's License (U.S. Department of Transportation, 2012).

The ability to drive provides adolescents a strong sense of independence as they gain more control over where and when they spend their time. Just as the elderly population is resistant to surrendering their Driver's License as their visual and cognitive

skills diminish with age (Johnson, 1995), adolescents similarly give high appraisal to holding a Driver's License. Usability of and access to a motor vehicle is seen as a means of escape from the controlling or limiting environment posed by young drivers' families (Best, 2006). In addition, driving maximizes opportunities for these "emerging adults" to explore additional social, academic and occupational experiences (Arnett, 2002).

Despite adolescents' eagerness to obtain a driver's license, this license is not simply obtained by passing a test based purely on driving ability. Obtaining a learner's permit, in most states, is a prerequisite to the road test¹. Therefore, prospective drivers typically have to first pass a learner's permit knowledge-based exam prior to attempting to pass their road-based driver's test (DMV.org, n.d.b). In order to pass the learner's permit test, test-takers must use the Driver's Manual to learn the rules, regulations, and procedures for safe driving. Drivers Manuals are published by individual states to reflect state-specific laws and regulations (DMV.org, n.d.a).

Attributes of Driving-Related Vocabulary Posing Challenges for Adolescents

While Driver's Manuals typically vary across states, what does not appear to vary is the multitude of vocabulary terms within them that are likely to pose a plethora of challenges for adolescents. For example, the vocabulary found in DMV manuals includes many words that are used quite infrequently during conversational speech. Frequency is known to play an important role in lexical development (e.g., Forster & Chambers, 1973; McKeown, Beck, Omanson & Pople, 1985; Ellis, 2002; Storkel, 2009; Whaley, 1978). Studies have found that it takes significantly longer to both identify and name low frequency words relative to high frequency words (e.g., Forster & Chambers, 1973;

¹ New Hampshire does not distribute learner's permits; requires passing a knowledge-based exam to obtain a Driver's License. New York exempts those who participate in a Driver's Education course from knowledge-based exam.

Strijkers, Costa, & Guillaume, 2010). Therefore, words like “yield,” or “rotary,” which are conversationally infrequent but important to learn and presented in the Driver’s Manual, are likely to be problematic for test-takers (Ellis, 2002). A second reason why the vocabulary in the Driver’s Manual may be challenging for adolescents to learn is because many of these words are quite long in length. Research has found that lengthy, unfamiliar words are more difficult to acquire than shorter words (Balota, Cortese, Sergent-Marshall, Spieler, & Yap 2004). Therefore, lengthy driving-related terms in Driver’s Manuals, such as “approaching” and “pedestrian” are likely challenging for adolescents to acquire. A third reason that vocabulary in the Driver’s Manual may be difficult to learn is because many of the terms are abstract. “Adjusting” and “oncoming traffic” are two examples. Abstract words, which are difficult to image, are more difficult to learn than concrete terms, which are highly imageable and capable of evoking sensorimotor perceptions (Kroll & Merves, 1986; McDonough, Song, Pasek, Golinkoff, & Lannon, 2011).

Interestingly, even familiar words can pose problems for adolescents trying to obtain a Driver’s License. For example, common words like “standing,” “tailgating,” and “shoulder,” may be more conversationally common, yet take on alternative meanings in the context of driving. New meanings to familiar words are difficult to grasp since individuals are required to suppress salient interpretations upon learning alternate definitions for these polysemous words (Johnson, Ionson, & Torreiter, 1997).

Additional Challenges of Driving-Related Vocabulary for Adolescents with LI

Children with LI, in particular, demonstrate difficulties that are likely to be compounded by the vocabulary selection on the learner’s permit test. LI is an impairment in which language deficiencies exist in the absence of hearing loss, intellectual

impairment, and other cognitive or neurological anomalies (Tallal, Ross, & Curtiss, 1989; Tomblin, Records & Zhang, 1996). A large body of work has documented vocabulary acquisition difficulties in children with LI (e.g. Alt et al., 2004; Conti-Ramsden, Botting, Simkin, & Knox, 2001; Eyer et al., 2002; Gathercole, 2006; Gray 2003; 2006; Gupta & Tisdale, 2009; Hick, Joseph, Conti-Ramsden, & Serratrice, 2002). During both direct instruction and incidental word learning tasks, children with LI recognize and produce fewer labels than their TD peers (e.g., Alt et al., 2004; Gray, 2003; Oetting, Rice, & Swank, 1995; Rice, Buhr, Oetting, 1992). Even in the face of multiple exposures to new words, children with LI exhibit significant problems with their retention (Oetting, 1999). Gray (2003) suggests that nearly twice as many exposures may be necessary for children with LI to master words with the same independence as their TD peers. For those words that children with LI do acquire, they exhibit less depth of knowledge of the vocabulary relative to similar-aged, unimpaired peers (Alt et al., 2004).

In addition to exhibiting challenges with low frequency, lengthy, abstract, and polysemous terms characteristic of vocabulary within Driver's Manuals (e.g., Balota et al., 2004; Forster & Chambers, 1973; Johnson et al., 1997; McDonough et al., 2011), there are a number of additional reasons why driving-related vocabulary may be particularly challenging for adolescents with LI. When taught novel labels for nouns and verbs, both TD children and those with LI have more difficulty responding to questions targeting verbs than nouns (Alt et al., 2004); however, the gap between noun and verb acquisition appears to be greater in those with LI (Oetting, 1999). When compared to younger, TD children with similar vocabulary ability, mean-length of utterance, and general oral language skills, those with LI have greater difficulty acquiring new verbs (Leonard, Bortolini, Caselli, & McGregor, 1992; Oetting, 1999; Owen Van Horne & Lin,

2011). Based on trends for verb-learning in those with LI, it is anticipated that all adolescents will have greater difficulty learning driving-related verbs, like "veering" and "scanning," than nouns, like "hood" and "rotary;" but, the magnitude of the difference between verbs and nouns would likely be larger for adolescents with LI than their unimpaired peers.

Although not investigated as extensively as nouns and verbs, there is some indication that children with LI will have more difficulty than unimpaired peers in acquiring compound nouns. Support for potential difficulty with compound nouns come from studies which demonstrate that children with LI stumble more frequently than age-matched, vocabulary-matched, and younger unimpaired peers when attempting to order and describe the semantic relationship between the root words within compound nouns (Grela, Snyder, & Hiramatsu, 2005; McGregor, Rost, Guo, & Sheng, 2010). This suggests that simple nouns from the Driver's Manual, like "ignition," may be easier for adolescents with LI to acquire than compound nouns, such as "gridlock." Different grammatical classes within compound nouns may also influence ease of acquisition. For example, we know that adjectives take longer to acquire than nouns during development (e.g., Caselli et al., 1995). Therefore, within the class of compound nouns, it may be more difficult for children to learn compound nouns comprised of adjective + noun combinations, than noun + noun combinations. In the context of the Driver's Manual, adjective + noun compounds, like "hazardous situation," may be more difficult to acquire than noun + noun combination, like "toll road." For adolescents with LI, who at a depressed rate tend to follow the typical developmental pattern for vocabulary (Kan & Windsor, 2010), it is possible that they would struggle to learn adjective + noun

compounds in the Driver's Manual at an age when compound nouns containing adjective modifiers are easily understood by typical peers.

The Importance of Understanding Driving-Related Vocabulary

Why is lexical knowledge likely important to mastering the material on the Driving Manual and ultimately passing the learner's permit test? When adolescents read the Driver's Manual, they are exposed to new vocabulary. They must sufficiently comprehend this vocabulary in order to understand scenarios presented and to answer them correctly on the learner's permit test, as well as to integrate this knowledge into the subsequent road test. Prior work has shown that reading comprehension suffers in the presence of a deficient lexicon, whether the lack of vocabulary understanding is due to a language impairment, language difference, or no language impairment at all (e.g., Marshall & Gilmour, 1990; Tao, 1994). Therefore, it is imperative that adolescents, who wish to secure the right to drive, master the driving-related vocabulary in order to fully comprehend the rules, regulations, and procedures for driving. Since failure to pass the learner's permit test inhibits one from earning a Driver's License and creates fertile ground for dispiritedness, it is worthy to investigate how well adolescents with LI, who are likely at an elevated risk of struggling with acquiring the driving-related vocabulary relative to unimpaired peers, comprehend the types of vocabulary presented within Driver's Manuals.

In summary, adolescents with LI are vulnerable to failing non-academic measures, like the learner's permit test, as a consequence of deficient vocabulary acquisition skills (Alt & Plante, 2006; Alt et al., 2004; Bashir, Wiig, & Abrams, 1978; Gray, 2003; 2006; Gray, Vance, & Henrichsen, 1999; Spaulding, Hosmer, & Schechtman, 2013; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998).

Specifically, the Driver's Manual and learner's permit test are expected to pose challenges for adolescents due to the multitude of sophisticated vocabulary words. Based on prior work (e.g, Alt et al, 2004; McGregor et al., 2010; Oetting, 1999), particular grammatical classes may be more challenging for adolescents with LI than for those without language impairment. If unable to comprehend vocabulary that is prevalent in the context of driving, adolescents' understanding of crucial ordinances and conventions for safe driving are likely to be impoverished. Failing to understand integral driving procedures can manifest in jeopardizing the safety of the adolescent driver and others on the road. Therefore, an investigation is warranted to determine if adolescents with LI have increased difficulty comprehending driving-related vocabulary relative to their unimpaired peers and if so, to determine what types of word classes are particularly challenging for those with this disorder.

The purpose of this study is to determine if adolescents with LI exhibit difficulties understanding vocabulary used in the Driver's Manual and on the learner's permit test. The performance of the LI group on a self-designed forced picture task containing driving vocabulary from Driver's Manuals will be compared to the performance of their TD peers. The central research questions include:

(1) *Does a self-developed forced picture task, the Driving-Related Picture Vocabulary Task, have high convergent validity with another vocabulary measure, the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn & Dunn, 2007)?*

The Driving-Related Picture Vocabulary Task is predicted to have high convergent validity with the PPVT-IV because both are designed to measure receptive vocabulary. The format and structure are the same as well, as both provide a vocabulary term and offer a field of four numbered picture response choices. Furthermore, both

include nouns, compound nouns, and verbs, although the PPVT-IV includes additional grammatical classes. Finally, normative data on the PPVT-IV is reflective of the receptive vocabulary scores for typically developing adolescents and adolescents with LI-samples tested on the Driving-Related Picture Vocabulary Task in the current study.

(2) Is there a relationship between the general oral language skills of adolescents and their performance on the Driving-Related Picture Vocabulary Task?

Receptive vocabulary scores on the Driving-Related Picture Vocabulary Task are anticipated to positively correlate with oral language skills, as measured on the Clinical Evaluation of Language Fundamentals—Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003), because both the Driving-Related Picture Vocabulary Task and the metric of general language functioning in this study rely on oral language skills. Prior work with adolescents demonstrates that typical oral language skills correlate with typical vocabulary sizes, and that persistent oral language problems correlate with smaller vocabularies (Stothard et al., 1998). Therefore, it is expected that oral language skills will increase with accuracy on the Driving-Related Picture Vocabulary Task.

(3) a) Is there a difference in performance between adolescents with LI and their typically developing (TD) peers on the Driving-Related Picture Vocabulary Task?

It is predicted that adolescents with LI will exhibit lower accuracy on the Driving-Related Picture Vocabulary Task, relative to TD peers. Since adolescents with LI have been found to have decreased receptive vocabularies compared to unimpaired adolescents (McGregor et al., 2013; Stothard et al., 1998), it is expected that their overall deficient word-learning skills will also impact their knowledge of terms specifically related to driving; words to which adolescents are not frequently exposed in their academic or daily conversational exchanges.

b) *If so, does it depend on grammatical class?*

It is expected that adolescents with LI will have varying degrees of difficulty for each tested grammatical class. Studies support that verbs are more difficult to acquire than nouns (Alt et al., 2004; Leonard et al., 1992; Oetting, 1999; Owen Van Horne & Lin, 2011), and within the noun class, compound nouns are harder to understand than simple nouns (McGregor et al., 2010). Accordingly, it is predicted that adolescents with LI will perform with saliently lower accuracy than TD peers when identifying verbs and compound nouns, as compared to simple nouns.

Method

Participants

Eleven adolescents with LI and 11 typically developing (TD) peers between the ages of 13 and 17 years were included in the study. See Table 1 for demographic characteristics. All participants were monolingual, English speakers, as determined by parental report, had yet to take the learner's permit test, exhibited normal hearing acuity per pure tone audiometry screening at 20 dB HL at 500, 1000, 2000, and 4000 Hz (American National Standards Institute, 2004), and exhibited normal range nonverbal intelligence with a standard score of 75 or higher on the Test of Nonverbal Intelligence—Fourth Edition (TONI-4; Brown, Sherbenou, & Johnson, 2010).

Table 1.
Demographic characteristics of participants

Variable	TD (<i>n</i> =11)	LI (<i>n</i> =11)
Age (months)		
<i>M</i>	198.36	193.00
<i>SD</i>	15.26	15.70
Sex		
M	7	7
F	4	4
Socioeconomic Status (years) ^a		
M	14.55	15.27
<i>SD</i>	1.51	1.90

Note. LI = language impairment; TD = typically developing.

^aSocioeconomic Status based on last year of maternal education completed

Group Placement. Diagnoses of LI were made using a multi-method procedure, requiring adolescents to (1) have a core composite score $\leq 1SD$ below the mean on the Clinical Evaluation of Language Fundamentals—Fourth Edition (Semel, Wiig, & Secord, 2003),

with a 100% sensitivity for identifying language impairment per the examiner's manual, (2) have previously received a diagnosis of language impairment or language learning disabled, (3) were currently receiving services for their language challenges, and (4) were judged as exhibiting impaired language skills by a speech language pathologist blind to the participants' group status.

TD status was also confirmed using a multi-method procedure. To be in the TD group, participants (1) scored $\geq 1SD$ below the mean on the CELF-4 (Semel et al., 2003), consistent with a 82% specificity for identifying typical language skills per the examiner's manual, (2) were judged as exhibiting typical language skills by a certified speech language pathologist blind to the participants' group status, and (3) per parent/guardian report, presented with no developmental concerns and a null history of special education or related services. See Table 2 for norm-referenced test results.

Table 2.

Norm-referenced test results

Behavioral measure	<i>TD</i>		<i>LI</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
**CELF-4 ^a	104.09	4.53	75.36	4.69
TONI-4 ^a	102.11	5.66	99.88	7.49
**PPVT-IV ^a	104.81	6.00	98.64	4.82

Notes. CELF-4 = Clinical Evaluation of Language Fundamentals—Fourth Edition (Semel et al., 2003); TONI-4 = Test of Nonverbal Intelligence—Fourth Edition (Brown et al., 2010); PPVT-IV = Peabody Picture Vocabulary Test—Fourth Edition (Dunn & Dunn, 2007); ** = significant difference at $p < .01$.

^aStandard scores with a mean of 100 and a standard deviation of 15.

Materials

A parent/guardian questionnaire was used to gather relevant demographic, educational, and medical history of the participants. A Micro Audiometrics Earscan 3 Manual Audiometer was used to screen for hearing acuity. A Quest Model 215 sound

pressure level meter was used for the experimental task. Auditory stimuli during the task were presented via Maxell nc-iv noise cancellation headphones. The TONI-4 (Brown et al., 2010) was used to ensure normal range cognition. The Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn & Dunn, 2007) was used in this study to validate the experimental task. The CELF-4 (Semel et al., 2003) was administered to acquire receptive and expressive language scores for determining presence and absence of language impairment. The Driving-Related Picture Vocabulary Task consists of 60 test items with a multiple-choice field of four. These 60 test items were chosen from DMV manuals in consultation with a Driver's Education instructor with over 15 years of experience. Test items target 15 driving-related vocabulary words for each grammatical class including Simple Nouns, Compound Nouns consisting of a noun + noun combination, Compound Nouns consisting of an adjective + noun combination, and Simple Verbs. See Table 3. for a list of the vocabulary terms by grammatical class. See Appendix A. for one example of the four picture choices (1 target, 3 foils) from each grammatical class.

Table 3.*Driving-related receptive vocabulary target words organized by grammatical class*

Simple Nouns	Compound Nouns		Verbs
	Noun + Noun	Adjective + Noun	
accident	airbag	bald tire	adjusting
automobile	gridlock	forked road	approaching
barrier	license plate	four way intersection	blocking
bicycle	pot hole	grooved pavement	crossing
collision	railroad crossing	handicapped parking	following
driver	road crew	hazardous situation	merging
hood	seatbelt	nonmoving object	parking
ignition	snow plow	oncoming traffic	passing
license	toll road	passing lane	reversing
obstacle	tow truck	recreational vehicle	signaling
officer	traffic congestion	sharp corner	skidding
pedestrian	traffic jam	two way traffic	steering
road	traffic light	wet conditions	stopping
rotary	transit bus	winding road	veering
shoulder	windshield	wrong way	yielding

Procedures

Preparation of Speech Stimuli. An undergraduate female student majoring in Speech, Language, and Hearing Sciences at the University of Connecticut served as the speaker of the vocabulary terms for the Driving-Related Picture Vocabulary Task. She was a native English speaker and spoke with a Standard American dialect. The 60 vocabulary words for the Driving-Related Picture Vocabulary Task were individually recorded in a quiet room using an Audio-technica AT-803 omni-directional condensor microphone that was positioned approximately 2.5 inches from the speaker's lips. Each word was recorded to Audacity at a sampling rate of 44.1 kHz and with 16-bit quantization.

Each speech stimulus was normalized using the Audacity program so that the peak amplitude of each word was constant across files. When the stimuli from the

Driving-Related Picture Vocabulary Task were presented to the listeners over headphones, the words were presented at an average 65 dB SPL. This was verified using a Quest Model 215 sound level meter.

The CELF-4 (Semel et al., 2003), TONI-4 (Brown et al., 2010), PPVT-IV (Dunn & Dunn, 2007), hearing screening, and Driving-Related Picture Vocabulary Task were administered to each participant in a randomized order. Testing occurred over a period of 1-2 days. The standardized tests were administered and scored according to the standard procedures of administration and scoring within their respective examiners' manuals. A \$15 monetary incentive was given to each participant following completion of testing and the Experimental task.

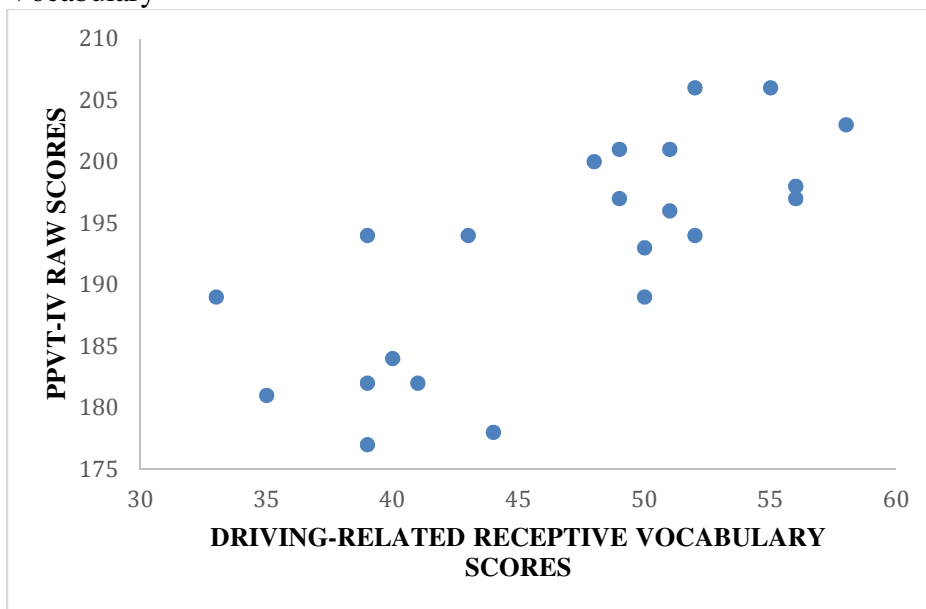
For the Driving-Related Picture Vocabulary Task, the participants wore noise-cancellation headphones and sat approximately 2 feet away from a Dell computer, which randomly presented the stimuli and recorded accuracy using the Direct RT software program (Empirisoft, 2008). In each trial, participants were presented with 4 picture choices, numbered 1 through 4, with one picture that matched the vocabulary word and three pictures that served as foils. Two seconds (2000 msec) after the four picture choices were presented, the participants heard the driving vocabulary term (i.e., obstacle), and were instructed to press the number (1-4) on the keyboard that corresponded with the picture that best represented that word. The 60 items were presented randomly, and the participants were given as much time as they needed to respond. Once the participant made a selection, the subsequent trial began 1500 msec after their response. The task typically took between 10-12 minutes to complete.

Results

Relationship Between Performance on Driving-Related Picture Vocabulary Task and Receptive Vocabulary Ability

To determine the relationship between performance on the experimental task, designed to measure driving-related receptive vocabulary knowledge, and a validated measure of receptive vocabulary functioning, raw scores on the Driving-Related Picture Vocabulary Task were compared to raw scores on the Peabody Picture Vocabulary Test-Fourth Edition (Dunn & Dunn, 2004). See Figure 1. The results revealed a statistically significant, positive relationship ($r = .74$, $p < .001$, $r^2 = .55$).

Figure 1. Relationship between Experimental Task Performance and Receptive Vocabulary



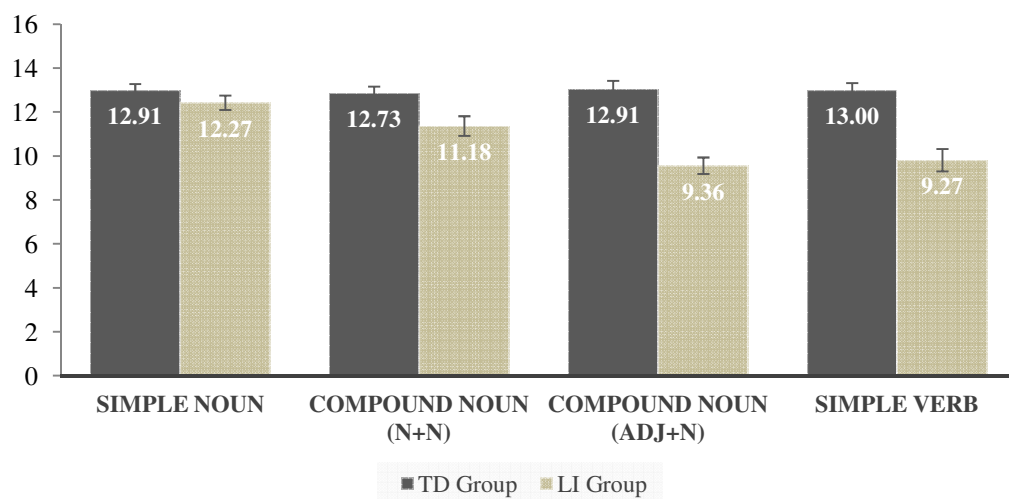
Group Differences on Driving-Related Picture Vocabulary Task

To determine how the adolescents with LI performed relative to the TD group, a mixed 2 x 4 ANOVA was conducted with Diagnosis (LI, TD) as the between-subjects variable and Grammatical Class (Simple Noun, Compound Noun (Noun + Noun), Compound Noun (Adjective + Noun) and Simple Verb) as the within-subjects variable.

Significant interactions were explored with planned post-hoc analyses, consisting of paired-t tests with a Bonferroni correction for multiple comparisons for within-subjects effects and Tukey HSD tests for between-subjects effects.. See Figure 2. for results.

The results revealed a significant main effect of Group ($F(1,20) = 16.24$, $p=.001$), with the LI group performing worse than the TD group on the experimental task. The results also indicated a significant effect of Grammatical Class ($F(3,60) = 11.50$, $p<.001$). The two main effects of Group and Grammatical Class were qualified by a significant Group x Grammatical Class interaction ($F(3,60) = 13.30$, $p<.001$). Post-hoc Tukey HSD analyses were conducted, revealing that the LI group performed similarly to the TD group in the Simple Noun condition ($t(20)=1.10$, $p=.29$), but performed significantly poorer than the TD group in the Compound Noun(Noun+Noun) ($t(20)=2.10$, $p=.049$), Compound Noun(Adjective+Noun) ($t(20)=5.40$, $p<.001$), and Simple Verb ($t(20)=4.88$, $p<.001$), conditions.

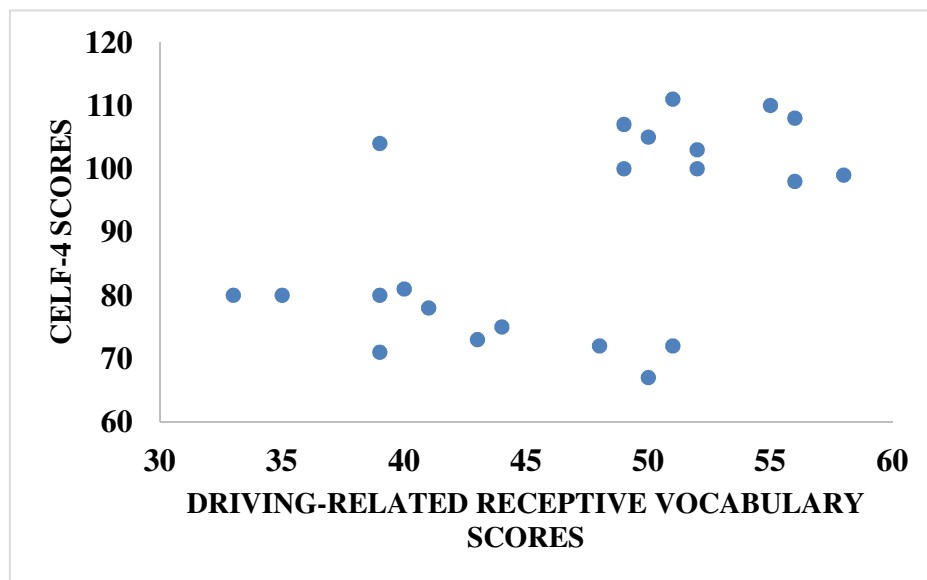
Figure 2. Group Performance on Driving-Related Picture Vocabulary Task



Relationship Between Performance on Driving-Related Picture Vocabulary Task and General Language Ability

Finally, to determine the amount of variance shared between performance on the Driver's Permit Task and general language functioning, a Pearson product moment correlation was conducted between Driver's Permit Test accuracy and our general language metric, the Core Language score of the CELF-4. See Figure 3. The results indicate a statistically significant, positive relationship ($r = .54$, $p = .01$, $r^2 = .29$).

Figure 3. Relationship Between Experimental Task Performance and General Language Skills



Discussion

The core goal of the current investigation was to determine if there is a difference in the understanding of driving-related terms for adolescents with LI compared to their unimpaired, typical peers. The findings support that such a disparity exists; The LI group, on average, understood fewer driving-related vocabulary terms than the unimpaired, control group. This significant difference likely places adolescents who suffer from LI at a disadvantage in understanding the rules, regulations, and procedures for safe driving practices. The likely consequence of this is twofold: First, they may be more likely to fail the learner's permit test, which is apt to include the vocabulary terms that adolescents with LI struggle to comprehend. Second, they are likely going to struggle to understand the rules, regulations, and procedures for safe driving practices. Therefore, if they pass the test, they may be at greater risk of placing others and themselves in danger on the road. Although there are no data to date on the driving abilities of those with LI, there is evidence that adolescents with ADHD, the disorder with the highest comorbidity with LI, exhibit unsafe driving practices (e.g., Barkley, 2004; Thompson, Molina, Pelham, Gnagy, 2007; Vaa, 2014; Winston, McDonald, McGehee, 2014). Adolescent drivers with ADHD receive a higher number of traffic citations and are involved in more motor vehicle accidents relative to age-matched peers without the disorder (Thompson et al, 2007). Research further supports that adolescents with Autism Spectrum Disorders, who also present with a language impairment, exhibit reduced safe driving behaviors (Cox, Reeve, Cox, & Cox, 2012; Reimer et al., 2013).

There is substantial heterogeneity within the LI population. Attempting to categorize LI into distinctive sub-groups has been challenging because the dynamic nature of LI makes individuals subject to transition across subgroups as they age (Conti-

Ramsden & Botting, 1999). Given this variability, another objective of the current study was to evaluate the relationship between general language functioning and performance on the experimental task. The results indicate a significant relationship exists: As language ability increases, so does performance on the Driving-Related Picture Vocabulary Task. The results reveal that 29% of the variability in performance on the Driving-Related Picture Vocabulary Task can be attributable to general language functioning. Although this analysis only included the participants with LI and the typical participants, the findings suggest that other populations that struggle with normal language acquisition, such as those with Autism Spectrum Disorder, intellectual disabilities, and perhaps even those with a history of language impairment, may also have substantial difficulty understanding the driving-related vocabulary within DMV manuals.

Although many children with LI exhibit poor vocabulary comprehension in general, not all do. Therefore, this study also investigated the relationship between receptive vocabulary, as indicated by scores on the PPVT-IV and performance on the experimental task. A strong correlation would provide validity for the Driving-Related Picture Vocabulary Task. The results support this correlation. Based on the comparisons between these two measures, 55% of the variability in the experimental task can be attributed to receptive vocabulary ability. This is also consistent with a large effect size (Cohen, 1988). This finding supports convergent validity of the experimental task for a measure of receptive vocabulary and indicates that those participants with LI who struggle with understanding vocabulary in general are at elevated risk for experiencing difficulty in understanding the driving-related terms within DMV manuals.

It is very likely that not all the vocabulary terms used within DMV manuals are difficult for adolescents to learn. Prior research has shown this to be the case (Kan &

Windsor, 2010; Leonard, Bortolini, Caselli, & McGregor, 1992; McGregor et al., 2010; Oetting, 1999; Owen Van Horne & Lin, 2011). The findings of this investigation support this prediction. The participants had an easier time understanding simple nouns than simple verbs and compound nouns consisting of an adjective and a noun. The results of this study provide us with an indication of what types of words are likely to be problematic for adolescents.

When comparing the performance of adolescents with LI and typical controls across word classes, it became apparent that the adolescents with LI struggled even more so with particular types of words found in DMV manuals. Specifically, there was a difference in performance between the two groups on verbs and compound nouns, regardless of the constitution of the compound nouns; however there was no difference between the two groups for simple nouns. It is not surprising that the LI group, as a whole, had difficulty comprehending verbs and compound nouns. Prior work has pointed to this possibility. Relative to unimpaired peers, children with LI have more difficulty understanding novel verbs and compound nouns, than simple nouns (Alt et al., 2004; Caselli et al., 1995; Grela et al., 2005; McGregor et al., 2010; Oetting, 1999). While those with LI develop vocabulary on a similar trajectory as TD peers (Kan & Windsor, 2010), the gap in vocabulary skills between children with LI and typical peers continues to widen as they move into adolescence. (Stothard et al, 1998).

This investigation is the first study to date to investigate adolescents' ability to comprehend the terms used in DMV manuals. There is currently a substantial body of work documenting the poor driving habits of adolescents relative to other aged drivers (e.g., Cohn, Macfariane, Yanez, Imai, 1995; Keating, 2007; Keating & Halpern-Flesher, 2008; Williams, 2007). While studies have focused on their increased impulsivity,

relatively reduced practice, and heightened distraction in the presence of passengers (e.g., Heck & Carlos, 2008; Mayhew & Simpson, 1990; Romer, Lee, McDonald, Winston, 2014; Williams, 2003; Williams, Ferguson, & McCartt, 2007), there may be an additional factor making them more likely to struggle with driving. They appear to be ill-equipped at understanding the terminology used to convey the rules and regulations drivers are expected to follow. This is particularly poignant for this study because >80% of the participants specified that they had studied for the learner's permit test and 40% indicated that they had studied "a lot". The higher risk of driving-related accidents in adolescents relative to older ages (e.g., Williams, 2003) may not be solely because of insufficient competency; it may also be due to insufficient comprehension. It is important to note, however, that none of the participants in this study were driving at the time of this investigation. Therefore, future work would have to be conducted to determine if this is the case.

What is the case, however, is that adolescents with LI are at increased risk of having difficulty understanding what they are reading within the Driver's Manuals because of the driving-related terminology used within the manuals. Testing accommodations offered by the DMV for those with disabilities, which include reading the test questions out loud for the test taker (California Department of Motor Vehicles, n.d.), are unlikely to facilitate improved comprehension of lexical items for those who struggle to comprehend them. Given the strong correlation between reading comprehension and listening comprehension (Nation & Stowling, 1998), presenting test questions via audio recording, or having an examiner read test items (two options offered by the DMV for those with disabilities), fail to address underlying vocabulary comprehension deficits for those with language impairment. Other available test

accommodations include having test items presented in a foreign oral or written language or American Sign Language (California Department of Motor Vehicles, n.d.); neither of which compensate for deficits resulting from language impairment. In addition, although Driver's Education courses are offered to prepare prospective drivers for safe driving practices, they typically do not cover explicit vocabulary elements of the exam; rather, practice test questions embedded with difficult DMV vocabulary are mainstream approaches for preparing students. Where this method of preparation may benefit TD adolescents, who respond better to incidental learning (Oetting, Rice, & Swank, 1995), it likely does little to help those, like adolescents with LI, who are at-risk of failing to learn DMV terminology. Furthermore, it may pose a hazard to themselves or others on the road if they are unable to learn important rules, regulations, and procedures for safe driving behaviors because they do not understand the terms used for their description.

Failing a high-stakes exam like the learner's permit test can have significant psychological and social implications. Adolescents who experience failure on high-stakes testing have been shown to demonstrate negative emotional responses, such as increased depression and embarrassment (Cornell, Krosnick & Chang, 2006). Failing to pass an exam perceived as high-stakes for the majority of adolescents, such as the learner's permit test, is likely to result in similar adverse emotional reactions. Such reactions are likely to be magnified for adolescents with LI who are at greater risk of experiencing behavioral, social, and emotional instability (Lindsay, Dockrell, & Strand, 2007), as well as exhibiting poorer social and emotional outcomes than their TD peers (Goldman, 1987; Tomblin, 2008; Yew & O'Kearney, 2013).

It is important to note that there are inherent weaknesses to the current investigation. First, there are many other types of vocabulary terms within DMV Driving

Manuals, which were not included within the current study. We selected grammatical classes that were easily imageable. Prior work has documented that terms which are more difficult to image are particularly challenging for children and adults (e.g., Kroll & Merves, 1986; McDonough, Song, Pasek, Golinkoff, & Lannon, 2011), including children and adolescents with LI (e.g., McGregor, Berns, Owen, Michels, Duff, Bahnsen & Lloyd, 2012). Therefore, our results may under-estimate the magnitude of difficulty that both groups of adolescents have with the terms used in DMV Driving Manuals. In addition, we only selected some terms within each grammatical class, as the stimuli were not exhaustive of the terms falling within each class on DMV Driving Manuals. Therefore, it is possible that we may have over- or under-specified the difficulty that both groups of adolescents have with comprehending these particular types of driving-related lexical terms. In addition, this investigation presented the vocabulary terms individually, without verbal context. Perhaps if the terms were presented within sentences, participants may have had an easier time at using the contextual information within the sentences themselves to help them to understand the vocabulary terms. However, the actual driver's manuals frequently include multiple challenging words within the same sentence (e.g., "You are not required to stop if the bus is traveling towards you and a median or other physical barrier separates the roadway;²" Connecticut Department of Motor Vehicles, 2014). While presenting the vocabulary terms in context may have facilitated participants' understanding of individual terms, presenting multiple terms within the same sentence, as is done in DMV manuals, may have decreased their performance because it would be harder to build off of the context to simultaneously comprehend multiple lexical items. In addition, we did not attempt to control for

² Underlines added to indicate challenging words within Driver's Manual

variables that could affect outcomes besides grammatical class, including degree of imageability, frequency, length, and whether or not they target words were monosemous or polysemous. Future analyses are under way to determine if these affected item-level performance. Finally, our LI group varied in their degree of reading competency. Although this investigation focused on oral language functioning, future work will explore if literacy skills contributed to group differences.

While the findings that adolescents with LI have more difficulty understanding particular driving-related terminology than TD peers suggest that this population could have more difficulty passing the learner's permit test, it would be gainful to determine if this were the case by directly comparing the scores and passing rates of those with and without LI on the learner's permit test. This may be the case because poor semantic knowledge is likely to impact understanding and accuracy of responses to questions on the learner's permit test. Many adolescents enroll in Driver's Education courses with the intention of becoming equipped to pass both the written and road test. For adolescents with LI, it is unknown whether or not typical programming is effective in mitigating their vocabulary deficits. Investigating the driving records of adolescents with and without LI before and after completion of Driver's Education, as well as making comparisons to their learner's permit test performance, could provide insight into the impact of mainstream preparation and subsequent comprehension of road safety. Adolescents with LI or other etiologies with consequent receptive vocabulary deficiencies, who fail to understand the rules and regulations for driving, may not only reveal their poor comprehension through written questions on the learner's permit test, but may indirectly reveal their poor receptive vocabularies in their number of driving violations. Perhaps, those with LI will have more tickets issued to them, more occurrences of revoked

licenses, or a higher likelihood of motor vehicle accidents, relative to their unimpaired peers due, in part, to their lack of understanding of vital driving-related information.

Typically, Russell Barkley's hierarchical model of driving (2004) is a dominant reference when considering driving competency for those with disabilities. The first level of the model, the operational level, consists of basic cognitive functions, including attention, visual scanning, and motor coordination. Subsequent levels include tactical and strategic levels, which refer to decision-making skills for driving in traffic and initiating motor vehicle use, respectively. Impairments impacting any level of Barkley's three-level hierarchy (2004) may be enough to deem someone unsafe for driving. Although it is sensible that competency in driving-related motor and cognitive skills included in the model should be considered for every driver, facilitating those with disabilities to become competent on the road should not be limited to addressing such skills. When an adolescent with LI reaches competency for each of Barkley's hierarchical criteria, but continues to have difficulty passing the learner's permit test, other factors need to be considered. Findings from the current study suggest that receptive vocabulary deficits, a frequently neglected skill set in relation to driving, have great potential to influence driving competency.

Other aspects of the material presented in the Driver's Manual may pose additional problems for understanding driving-related information. Beyond the challenges for acquiring semantic knowledge, the Driver's Manual also contains a myriad of complex syntactic structures. Study questions presented in driver's manuals, which are designed to be representative of learner's permit test questions, include complex sentence structure with multiple clauses. For example, in response to the study question probe, "Which statement is false?," choices include lengthy, complex clause structures, like

“After market, any changes to equipment, such as tinted windows, are legal”

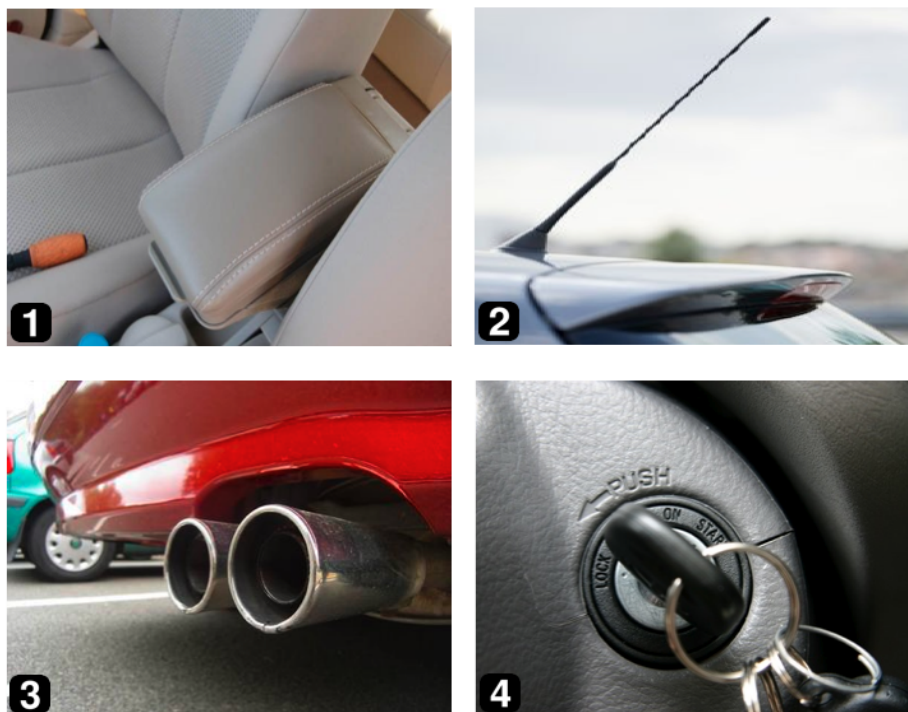
(Connecticut Department of Motor Vehicles, 2014). Such responses require strong skills for comprehending how main clauses and relative clauses relate. Syntactic comprehension errors, especially for sentences including relative clauses, have been shown to be significant for children and adolescents with LI as compared to their TD peers (Adani, Forgiarini, Guasti, and Van der Lely, 2014; Friedmann & Novogrodsky; Stavrakaki, 2001). Adani et al. (2014) report that children and adolescents with specific LI made significantly more errors, relative to younger TD vocabulary-matched controls, when selecting pictures to match sentence stimuli for relative clauses with subjects, as well as objects. Since syntax also provides the context to aid semantic learning for abstract words, poor syntactic comprehension can influence comprehension on lexical levels (McGregor et al., 2012). Consequently, the combination of challenging vocabulary and complex syntactic structure is likely to exacerbate comprehension difficulties both with the study preparation materials provided by the DMV and with the learner’s permit test.

Procuring a greater understanding of the nature of vocabulary and other linguistic demands presented in materials and assessments requisite for earning a Driver’s License have important implications for Speech-Language Pathologists (SLP). Special education service providers, including SLPs, are mandated under the Individuals with Disabilities Education Act (2004) to provide transitional services to qualifying school-age children and adolescents with disabilities. Transition services target improved functional achievement for easing the changeover from school to post-school life (TITLE I.A.604.34.A; Individuals with Disabilities Education Act, 2004). Functional activities incorporated in transition services include “adult living objectives” (TITLE I.A.604.34.C;

Individuals with Disabilities Education Act, 2004), which should encompass driving for those whom it is appropriate. The ability to drive helps to meet adult transitional needs related to social and vocational achievement. Transportation privileges expand opportunities for participation in social activities and occupational choices both during and following the school years by providing access to events and jobs in a broader region. Adolescents with high functioning Autism Spectrum Disorder, who exhibit communication impairments like adolescents with LI, often do not have driving goals included in their Individualized Education Plans, even when they are actively receiving some form of driver's training (Huang, Kao, Curry, & Durbin, 2012). Acknowledgement of the significance of transition services, and awareness of the lexical challenges that those with LI face with taking the learner's permit test, should lead SLPs to consider the importance of targeting driving-related vocabulary as a means of improving functional and transitional achievement. Findings from the current study should provide insight into which types of driving-related terms will likely need the most attention during intervention.

Appendix A.

Example picture choices for Simple Noun stimulus: “ignition”



Example picture choices for Compound Noun (Noun + Noun) stimulus: “pot hole”



Example picture choices for Compound Noun (Adjective + Noun) stimulus: “recreational vehicle”



Example picture choices for Simple Verb stimulus: “veering”



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