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Learning by Listening to Lectures is a Challenge for College Students with Developmental Language Impairment

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Abstract

Background: Increasing numbers of students with developmental language impairment (LI) are pursuing post-secondary education.

Objective: To determine whether college students with LI find spoken lectures to be a challenging learning context.

Method: Study participants were college students, 34 with LI and 34 with normal language development (ND). Each took a baseline test of general topic knowledge, watched and listened to a 30-minute lecture, and took a posttest on specific information from the lecture. Forty additional college students served as control participants. They completed the tests that covered the lecture information without being exposed to the lectures.

Results: With baseline performance controlled, students with LI performed more poorly than students with ND on multiple choice and fill-in-the-blank questions that tapped the lecture material. Nevertheless, students with LI out-performed the control participants whose scores were at floor. A self-rating of attention to the lecture predicted learning performance for both study groups; performance on a sentence repetition test, a measure that taps both prior linguistic knowledge and operations in short-term memory, was an additional predictor for participants with LI.

Conclusion: College students with LI learn less from listening to lectures than other students. Working memory deficits, especially those that reflect weaknesses in the central executive and the episodic buffer, may contribute to the problem.

1. Introduction

1.1 Background

Developmental language impairment (LI, also known as specific language impairment or primary language impairment) is typically diagnosed in childhood but it can limit academic

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outcomes and other psycho-social functions well into the adult years (Clegg, Hollis, Mawhood, & Rutter, 2005; Elbro, Dalby, & Maarbjerg, 2011; Whitehouse, Watt, Line, & Bishop, 2009). For example, people from a community-based sample who were identified with LI at age 5 years continued to achieve well below academic grade level at 19 and they were 10.7 times more likely than unaffected same-age peers to meet criteria for learning disabilities in reading and math (Young et al., 2002).

Nevertheless, comparisons between outcome studies conducted in the 1990s and the 2000s reveal a hopeful change, an increase in the number of people with LI who earn secondary degrees and who continue into post-secondary education (Durkin, Simkin, Knox, & Conti-Ramsden, 2009). This change is part of a more general trend towards an increased presence of students with disabilities on college campuses (Newman et al., 2011). The trend is likely to be specific to countries where reforms in educational policies have led to better supports in secondary classrooms and better transition planning for post-secondary options. In England, for example, recent decades have brought a shift away from special schools to mainstream placements for students with special education needs, a greater emphasis on access to the National Curriculum for students with special needs, and more professionals, mentors, and advisors to support students with special needs (Lindsay, Dockrell, Joffe, Cruice, & Chiat 2008). The United States is another example. As of 2004, U.S. federal law requires that Individualized Education Plans for students who are 16 years or older include goals for transitioning to post-secondary training, education, employment, and independent living (U.S. Department of Education, 2004).

Despite these advances, students with LI who enter post-secondary studies will likely face real challenges. In a recent nation-wide survey of university students in the U.S., those with learning disabilities (on this survey, a broadly-defined category that would include students with LI) reported more difficulty with assignments, more skill-based and non-academic obstacles to success, and less satisfaction with their university experience than other students (McGregor, Lagenfeld et al., 2016). Two types of media predominate in the typical post-secondary course, textbooks and lectures (Rose, Harbour, Johnston, Daley, Abarbanell, 2006). The purpose of the current study was to examine the challenges that lectures present for post-secondary students with LI.

The functional impact of LI on the processing of classroom lectures has been examined previously. Ward-Lonergan, Liles, and Anderson (1998) asked junior high school students with and without LI to listen to two video-taped lectures about a fictitious country and then verbally answer literal and inferential questions about the content of the lectures. On both lectures and both question types, the students with LI recalled less information than the students without LI and the effect size was moderate.

Do older students with LI, those who manage their disability well enough to gain admission to college, continue to exhibit such difficulties during lectures? Existing survey data suggest this is likely. On one survey, two-thirds of students with dyslexia, a related and sometimes co-morbid disorder, reported barriers to learning during lectures having largely to do with the speed of the lecture presentation (Fuller, Healey, Bradley, & Hall, 2004). One quantitative study is also relevant. Einstein, Morris, and Smith (1985, experiment 2) divided

students into groups with higher or lower grade point averages (GPAs), presented them with a video-taped lecture, then asked them to write down as much of the lecture content as they could recall. The recall probe was administered to half of the participants 5 minutes after the lecture and to the other half one week later. The expected performance gap between students with low and high GPAs was obtained at both time points, and that gap was steady over time; therefore, compared to the more successful students, the less successful students encoded less from the lecture but were no more likely to forget the information that they had encoded.

The current study builds this evidence base in a number of ways. First, we sorted the students by diagnosis (i.e., LI or ND), rather than GPA. Second, because we wished to isolate learning in the moment from limitations in knowledge that had accrued over time, we administered a test of baseline knowledge before the lecture task and factored the scores out of our statistical model. Third, because we were interested in isolating potential deficits in spoken language processing from deficits in reading and writing, we used lectures with minimal textual support and we did not allow the students to take notes. This is a rare procedure in the literature on learning from lectures; very few published studies have isolated learning via listening from learning via note-taking.

There are practical advantages in examining learning from lectures in the absence of note-taking. Students with LI write more slowly than other students (Dockrell, Lindsay, & Connelly, 2009); therefore, they might have someone else take notes for them, a standard accommodation at the post-secondary level (Kurth & Mellard, 2006). Alternatively, they might prefer to take notes via keyboard rather than longhand, but taking notes in longhand is a better aid to memory encoding (Mueller & Oppenheimer, 2014). Finally, those students with LI who do take notes longhand may have difficulty prioritizing ideas while writing (Dockrell et al., 2009). In fact, note-taking could interfere with learning in that, in real lecture contexts, the cognitive resources required to attend simultaneously to multiple modalities may be too great for students with LI and related disabilities (Beacham & Alty, 2006). This is not to say that **review** of notes would not be useful for students with LI; it is (Boyle & Rivera, 2012). What we argue here is that many students with LI are not well-positioned to benefit from note-taking as a memory encoding strategy. Therefore, as an initial step toward understanding the challenges faced by students with LI in the college classroom, it is important to determine what they glean by merely listening to lectures.

1.2 Theoretical Framework

At the most general level, to learn from a lecture, the student must comprehend and remember the material. People with LI have problems with both listening comprehension (Montgomery, 2000; Plante, Ramage, & Magloire, 2006; Ward-Lonergan et al., 1998) and memory (Isaki & Plante, 1997; Isaki, Spaulding, & Plante, 2008; McGregor et al. 2013; McGregor, Arbisi-Kelm, & Eden, 2016; Sheng, Byrd, McGregor, Zimmerman, & Bludau, 2015).

Theoretical models of working memory offer a more nuanced understanding of how weaknesses in comprehension and memory might detract from learning, especially for learners with LI. Working memory is a limited-capacity system for processing and

temporarily storing information (Baddeley & Hitch, 1974). Processing involves the construction of representations of input at various levels (e.g., lexical, grammatical, propositional) thereby allowing comprehension, whereas storage is retention of those representations (Just & Carpenter, 1992). Baddeley (2003) models working memory as multiple, interactive processing components: the phonological loop temporarily stores verbal-acoustic information; the visual-spatial sketchpad temporarily holds visual information; the episodic buffer binds visual and verbal-acoustic information and information from short-term and long-term stores; and the central executive allocates attentional focus to relevant information, sustains or switches focus as needed, and inhibits focus to irrelevant information. These fluid systems interact with crystallized, or long-term systems. For example, processing familiar information (i.e., information stored in long-term memory) does not task the limited capacity fluid systems to the same extent as processing novel information (Mainela-Arnold and Evans, 2005).

Importantly, the interaction between the fluid and crystallized systems is how new information is learned. Because the fluid systems are of limited capacity when the demands of comprehending are too high, long-term storage—also known as learning—will suffer (Daneman & Carpenter, 1983). This gateway to learning is especially vulnerable in individuals with LI, who, in comparison to age-mates, have reduced working memory capacity, slower processing, reduced attentional capacity, poorer inhibitory control, and less developed systems of existing linguistic knowledge (see review in Montgomery, Magimairaj, & Finney, 2010).

Two tasks that tap aspects of working memory are used extensively in research on LI: nonword repetition and sentence repetition. Nonword repetition tasks require participants to listen to and imitate a string of sounds, one after the other. Poor nonword repetition is so characteristic of LI that it is considered a reliable clinical marker (Archibald & Joanisse, 2009). When care is taken to create nonwords that do not closely resemble real words (Gathercole, 1995) and do not contain syllables that are real words (Dollaghan, Biber, & Campbell, 1995), nonword repetition is interpreted to be a measure of the integrity of the phonological loop (Gathercole, 1995), although long-term vocabulary knowledge still influences the results (Metsala, 1999).

Sentence repetition tasks also require the participant to listen and imitate a string of sounds but, in this case, the sounds comprise real words organized into meaningful sentences. Sentence repetition is an even more accurate clinical marker of LI than nonword repetition (Conti-Ramsden, Botting, & Faragher, 2001). Sentence repetition taps many systems. Performance on the task correlates with performance on a measure of short-term memory (nonword repetition, Conti-Ramsden et al., 2001), as well as measures of long-term memory (grammar and vocabulary knowledge, Riches, Loucas, Baird, Charman, & Simonoff, 2010; Stokes, Wong, Fletcher, & Leonard, 2006). Riches (2012) identifies problems with redintegration—or the use of long-term memory to support short-term memory processes by chunking the to-be-imitated sentence into larger units—to be a deficiency underlying the poor sentence repetition skills demonstrated by people with LI. In terms of Baddeley's 2003 model of working memory, sentence repetition taps the function of the episodic buffer, for this is where the integration of short-term information (the sentence just presented) and

long-term information (the person's existing knowledge of the words and the structure that characterized that sentence) will occur (Baddeley, Hitch, Allen, 2009; Poll, Miller, & van Hell, 2016).

Baddeley's 2003 model of the components of working memory frame the current study. After determining whether there are differences in learning outcomes between students with and without LI, we can explore the components of working memory that contribute to the profile of learning in the LI group.

1.3 The Current Study

The approach was to compare learning from spoken lectures in two groups, college students with LI and those with ND. Given the range of deficits affecting the verbal learning of students with LI, we predicted that students with LI would be less able than peers with ND to answer comprehension questions correctly after listening to the lecture.

A secondary question concerned how the response format of the post-test affected performance. Half of the questions were fill-in-the-blank. Thus, they tapped the expression of newly learned material. Half were multiple choice; thus, they tapped the recognition of newly learned material. Both are typical test questions in undergraduate classrooms; however, expressive recall tests are more sensitive to differential learning outcomes (Campbell & Mayer, 2009; Kobayashi, 2005). Of particular relevance, the expressive format is more sensitive to the memory encoding deficit that characterizes individuals with LI (McGregor et al., 2013). Therefore, we predicted that the LI-ND performance gap would be more apparent on the fill-in-the-blank questions than the multiple-choice questions.

Finally, as an exploratory step, we asked which mechanisms of learning are deficient. We were interested in tapping four of the five components of working memory as proposed by Baddeley (2003): to measure the phonological loop we used a nonword repetition task; to measure the episodic buffer, we used a sentence repetition task; to measure the central executive we used an attention rating scale, and to measure the long-term lexical systems we used a receptive vocabulary test. We did not attempt to measure a fifth component of the model, the visual-spatial sketchpad because the lecture involved minimal visual information. We asked whether any of the measures correlated with learning performance in the LI and ND groups.

To summarize, the specific research questions were:

- Do college students with LI learn less information than college students with ND when listening to lectures? We predicted that this would be so.
- If so, is the deficit evident on both recall (fill-in-the-blank) and recognition (multiple choice) questions? We predicted a greater performance gap on recall than on recognition.
- Is the amount of learning within the group of participants with LI predicted by scores on measures that tap the phonological loop, episodic buffer, central executive, and long-term lexical knowledge? Do these same predictors capture

individual differences within the group of participants with ND? As this question was exploratory, we made no firm predictions.

2. Method

2.1 Participants

Study participants were 68 college students from the American Midwest whose ages ranged from 18 to 25 years. All were recruited and tested in accord with an approved IRB procedure. Of the 68 participants, 34 (16 females) reported an LI diagnosis and 34 (16 females) had ND. LI and ND groups were matched for sex and type of post-secondary institution (university, four-year college, community American, and 1 college). Within the LI group, 30 students were Caucasian, 2 were African American, 1 was Native did not report. Three students were Hispanic, 24 were not, and 7 did not report. Within the ND group, 30 students were Caucasian, 1 was African American, 1 was Native American, and 2 were Asian. Four students were Hispanic, 26 were not, and 4 did not report. The students with LI averaged 20.69 years of age ($SD = 1.7$) and those with ND averaged 21.13 ($SD = 1.6$), $t = 1.11$, $df = 66$, $p = .27$. The students with LI had completed 13.9 years of education ($SD = 1.5$) and those with ND had completed 14.6 ($SD = 1.65$), $t = 1.8$, $df = 64$, $p = .08$.

The LI group was heterogeneous in date of diagnoses, the earliest diagnosis being second grade and the latest being upon entry to college. To verify the self-reported LI and ND diagnoses, we used a procedure and weighted score cut-off demonstrated to maximize the sensitivity and specificity of identification of developmental LI in young adults (Fidler, Plante, & Vance, 2011). The procedure comprises a spelling test and a sentence comprehension test (Table 1). The spelling test contains 15 irregularly spelled words that the examiner reads aloud to the participant in isolation, in a sentence, and again in isolation. The participant writes the words and each is scored as correct or incorrect. The sentence comprehension test is a modification of the Token Test that contains 44 sentences that instruct the participant to carry out tasks with colored shapes (e.g., touch the yellow square before you touch the blue circle). The participant's enactment of each instruction is scored as correct or incorrect. As instructed in Fidler et al. (2011), the scores from each test are multiplied by a weighting value, summed, added to a constant (see constants in Fidler, Plante, & Vance, 2013). Positive values are indicative of LI. Given the results of the Fidler et al. (2011) procedure, we excluded 10 potential participants from the study: eight earned a negative score but reported LI and two earned a positive value but reported no history of LI.

Additional enrollment criteria were: a passing performance on a pure-tone hearing screening presented at .5, 1, 2, and 4k Hz at 20dB bilaterally (ASHA, 1990), no positive history of acquired neurological disorders, and English as the primary language. We did not exclude students with ADHD as this condition is often co-morbid with LI (Mueller & Tomblin, 2012). The final number of study participants was 68, 34 with LI and 34 with ND.

To further describe the study participants, we had them complete a battery of standardized and nonstandardized assessments, including the Peabody Picture Vocabulary Test – 4th Edition (PPVT-IV, Dunn & Dunn, 2007), the Expressive Vocabulary Test – 2nd Edition (Williams, 2007), the Word Definition and Recalling Sentences subtest of the Clinical

Evaluation of Language Fundamentals (Semel, Wiig, & Secord, 2003), a nonword repetition task (Dollaghan & Campbell, 1998), the Conners' Adult ADHD Rating Scale – Self Report – Screening Version (Conners, Erhardt, & Sparrow, 1999), and the Kaufman Brief Intelligence Test – 2nd Edition (KBIT; Kaufman & Kaufman, 2004). As consistent with the diagnoses, the ND group outperformed the LI group on all tests except for the KBIT (Table 1).

Three of these assessments were included specifically because we wished to consider their value for predicting learning performance. These were the PPVT-IV, a measure of extant vocabulary; the nonword repetition task, a measure of the phonological loop; and the Recalling Sentences subset of the CELF-3, a measure of the episodic buffer. The CELF-3 Recalling Sentences, in particular, was selected because of its utility in predicting the recall and comprehension of oral narrative in young children with LI (Dodwell & Bavin, 2008). It also differentiates between adults, ages of 18;0 and 25;11, who do and do not have LI with a high degree of accuracy (Poll, Betz, & Miller, 2010).

We recruited 40 additional students from an introductory college course as a means of controlling for the possibility that the posttests were simple enough to answer on the basis of general knowledge or that the questions themselves were highly guessable. Each control participant took both the philosophy and physics post-tests without watching or listening to the lectures. If we had successfully written a test that tapped the learning of new information, the control participants should perform near floor.

2.2 Materials

The materials were a baseline test tapping general knowledge of physics or philosophy, the lectures themselves, and a post-test tapping information from the lectures.

The information tapped in the baseline test was typical of that presented in an introductory course; the test did not cover any information specific to the lectures. Each test consisted of 10 multiple-choice questions and 10 fill-in-the-blank questions. The first author developed the test questions by gathering information from textbooks, presentations and her class notes (see Appendix).

Both 30-minute lectures came from The Great Courses® DVD series: “Socrates on the Examined Life” (from The Great Ideas of Philosophy, Robinson, 2004) and “Enter the Quantum” (from Physics and Our Universe: How It All Works, Wolfson, 2000). Both videos featured a male professor lecturing. We chose two lectures because a) we wanted to demonstrate that our results were not specific to any given lecture or type of material and b) we wanted to ensure that participants were learning material that was not an area of expertise for them. We chose these lectures in particular because of their similarity, in content and presentation, to what students might encounter in college classrooms. Because we were interested in learning via listening, we also took pains to select lectures with minimal visual supports. Nonetheless, there were some visuals. Visual supports in the philosophy lecture included two quotes written in Latin and English, eight short written texts of 3 or fewer words, and four visual depictions (paintings and sculptures) that accompanied the short texts. Visual supports in the physics lecture included two diagrams (one of which

was shown twice, the second time with increased complexity), two written texts of 3 or fewer words, two photos that accompanied the short texts, and one equation with labels and definitions (shown five times, each time with increased complexity).

The first author developed questions for the post-test directly from the lectures presented; the test did not tap broad or basic concepts in physics or philosophy. Each test consisted of 20 questions, ten multiple choice and ten fill-in-the-blank. To determine the suitability of these questions, a pilot study of eight college students with ND was performed. Four watched the philosophy lecture, and four watched the physics lecture. Scores ranged from 9 to 19 (out of 20), thus reducing concern that the questions would elicit floor or ceiling-level performances.

2.3 Tasks for Study Participants

At the beginning of the session, each participant was interviewed by an examiner regarding experience with the topics of Physics and Philosophy. The interview questions were: Have you had any college level courses in Philosophy? If so, which?; How would you rate your knowledge of Philosophy on a scale of 1 to 5, 1 being “I have no knowledge of Philosophy” and 5 being “I am very knowledgeable in Philosophy;” Have you had any college level courses in Physics? If so, which?; How would you rate your knowledge of Physics on a scale of 1 to 5, 1 being “I have no knowledge of Physics” and 5 being “I am very knowledgeable in Physics.”

To reduce the possibility that the lecture posttest performance was influenced by prior general knowledge of the topic, participants were then assigned to watch a lecture on the topic that was less familiar (without exception participants indicated greater familiarity with one topic or the other). Within the LI group, there were 21 students in the philosophy condition and 13 in the physics condition. Within the ND group, there were 20 in the philosophy condition and 14 in the physics condition.

Participants completed the baseline test, watched and listened to one of the 30-minute lectures, reported his or her attention to the lecture on a 7-point Likert scale (1 being not attentive at all and 7 being very attentive) and, immediately after, completed the lecture posttest. Before the lecture began, they were advised to listen as they would to any other lecture. They were asked to refrain from taking notes or using their phone. They were also told that they would be asked to answer questions about lecture content when the lecture was over.

Due to investigator error, only 17 participants with LI and 13 participants with ND rated attention. Participants were assured that any answer on the attention rating scale was acceptable, as to encourage them to be honest and accurate even if they were not paying attention to the lecture.

2.4 Tasks for Control Participants

The students in the control group participated in post-tests only. Each control participant took both the philosophy and physics post-tests without watching or listening to the lectures.

3. Results

As a preliminary step, we compared baseline performance by group and topic to determine whether or not the LI and ND groups presented with different levels of background knowledge and whether the topics were differentially difficult. For multiple choice questions, an ANOVA with group and topic as between-subject factors and proportion of questions answered correctly as the dependent variable revealed no significant differences in performance by topic (philosophy $M = .42$ with $SE = .03$, physics $M = .50$ with $SE = .03$, $F(1,64) = 3.50$, $p = .065$ partial $\eta^2 = .05$), or group (ND $M = .49$ with $SE = .03$, LI $M = .43$ with $SE = .03$, $F(1,64) = 1.35$, $p = .25$). However, on fill-in-the-blank questions, there was a significant topic difference (philosophy $M = .22$ with $SE = .03$, physics $M = .42$ with $SE = .04$, $F(1,64) = 15.81$, $p = .0002$, partial $\eta^2 = .20$) as well as a significant group difference (ND $M = .40$ with $SE = .04$, LI $M = .23$ with $SE = .04$, $F(1,64) = 11.73$, $p = .001$, partial $\eta^2 = .15$). Judging from effect sizes, all statistically significant differences exceeded minimum cut-offs for practical significance as well (Ferguson, 2009). Given the difference between topics, we retained topic as a factor in subsequent analyses.

The primary question was whether or not the ND group learned more from the lectures than the LI group. We answered this with two Analyses of Covariance (ANCOVA), one for multiple choice and one for fill-in-the-blank questions, with group and topic as between-subjects factors, baseline performance and years of education as covariates, and proportion correct on the post-lecture test as the dependent variable. For multiple choice questions, there was a main effect of group (ND $M = .73$ with $SE = .03$, LI $M = .55$ with $SE = .03$, $F(1,60) = 15.87$, $p = .0002$, partial $\eta^2 = .21$) but no effect of topic ($F(1,60) = 1.38$, $p = .24$) (Figure 1). Neither baseline performance nor years of education were significant covariates ($p > .15$). For fill-in-the-blank questions, there was also a main effect of group (ND $M = .67$ with $SE = .03$, LI $M = .46$ with $SE = .03$, $F(1,60) = 8.48$, $p = .005$, partial $\eta^2 = .12$) but again, no effect of topic ($F(1,60) = 1$). There was no effect of education ($p > .15$) but there was a significant effect of baseline performance, $F(1,60) = 7.06$, $p = .01$, partial $\eta^2 = .11$, showing that fill-in-the-blank performance at post-test was related to fill-in-the-blank performance at baseline. Again all statistically significant effects exceeded a recommended minimum cut-off for practical significance (Ferguson, 2009).

To ensure that the low performance demonstrated by the LI group reflected problems with learning from the lecture rather than test-taking *per se*, we compared the performance of the LI group to the performance of the control participants. Because the control participants scored near floor, the data were not normally distributed; therefore, we applied two nonparametric Mann-Whitney U-tests. The LI group outperformed the control group on the philosophy questions, $z = 5.97$, $p < .01$, $r = .72$, and on the physics questions, $z = 6.26$, $p < .01$, $r = .76$; both effect sizes were of moderate practical significance (Ferguson, 2009) (Figure 2).

For the LI group, posttest performance was correlated with receptive vocabulary ($r = .37$, $p = .03$, a minimum practical effect) and sentence repetition ($r = .55$, $p = .001$, a moderate practical effect) but not nonword repetition ($r = .18$, $p = .31$). For the ND group, posttest performance was correlated with receptive vocabulary ($r = .50$, $p = .003$, a moderate

practical effect) but not sentence repetition ($r = .27$, $p = .115$, a minimum practical effect) or nonword repetition ($r = .09$, $p = .63$) (Ferguson, 2009).

The lack of correlation between posttest performance and nonword repetition in both groups raises concerns that the restricted range of the nonword repetition scores, a range of 13 points for the ND group and 20 points for the LI group (see Table 1), prevented a sensitive test. Reasoning that nonword repetition and sentence repetition should correlate, because phonological short-term memory plays a role in both, we tested the sensitivity of the nonword repetition scores by correlating the two. The result was that nonword repetition and sentence repetition correlated significantly and with a moderate effect size for both groups, ND: $r = .53$, $p = .001$; LI: $r = .50$, $p = .003$. Therefore the null findings involving nonword repetition do not appear to be a measurement artifact.

Given that two variables predicted the learning outcomes of the LI group, the next step was to determine which of the two was stronger. For the LI group, sentence repetition and receptive vocabulary scores were correlated with each other at $r = .52$, $p < .05$. With a correlation less than .70, concern about multi-collinearity was low (Tabachnick & Fidell, 2007), so we proceeded to enter both predictors into a regression model to determine which variable better accounted for individual differences within LI group performance. The overall model accounted for 32% of the variance in post-test performance, $F(2, 31) = 7.09$, $p < .003$. Sentence repetition was a significant predictor with a greater than minimum practical effect, $\hat{\beta} = 0.49$ SE of $\hat{\beta} = 0.17$ partial correlation = .45, $t(31) = 2.81$, $p = .009$, but receptive vocabulary was not correlated statistically or practically, $\hat{\beta} = 0.12$ SE of $\hat{\beta} = 0.17$ partial correlation = .12, $t(31) = 0.67$, $p = .51$ (Ferguson, 2009).

Finally, we explored the role of attention to the lecture. Compared to participants with ND ($M = 4.57$, $SE = 1.7$), participants with LI rated their attention to the lecture lower ($M = 3.52$, $SE = 1.34$). Although this difference was not statistically significant, $t = 1.89$, $df = 28$, $p = .07$, the effect size, $d = -.69$, exceeded a minimum for practical significance. The self-rating of attention correlated with post-test performance for the ND group ($r = .64$, $p = .02$) and the LI group ($r = .55$, $p = .02$); both correlations were of moderate practical significance (Ferguson, 2009).

4. Discussion

On average, students with LI learned about 20% less from listening to a college lecture than their peers with ND. We predicted that the performance gap would be greater on recall questions. Although this was the case on the pretest of general knowledge, on the posttest of learning from lecture, the difference between groups was moderate in size on both question types, accounting for 20% and 15% of the variance in multiple choice and fill-in-the-blank performance, respectively. Finally, in the absence of central executive and the episodic buffer, predicted specific predictions, we found scores on measures that tap two components of working memory, the learning performance in the LI group. Below we explore these predictors in more depth and consider the practical implications of these findings.

4.1 Why is it Difficult for Students with LI to Learn from Lectures?

Before proceeding, we will critically examine the conclusion that learning was hard for the students with LI. One might conjecture that it was not learning at all, but the expression of learning, that mattered in this study. The students with LI had to read the test questions and write the answers, and reading and writing are core challenges for these students (Clegg et al., 2005; Dockrell et al., 2009; Elbro et al., 2011). Although a pen-and-paper test was ecologically valid, it potentially limited their performance. Nevertheless, it seems unlikely that it was the sole basis for their low performance. They had to read the multiple choice questions on the baseline test, and they performed as well as their ND peers. Also, we did not count misspellings or grammatical mistakes as errors on the fill-in-the-blank questions. Finally, previous studies that tested learning in a purely spoken modality revealed a similarly sized ND-LI gap (McGregor et al., 2013).

If this conclusion is accepted, the critical question becomes why: why is it difficult for students with LI to learn from spoken lectures? We shall frame answers to this question by referring to Baddeley's (2003) model of memory that emphasizes the role of the central executive, the phonological loop, the episodic buffer, and long-term memory in the initial stages of learning.

Executive functions that marshal attention to relevant information (e.g., a new physics term), and inhibit attention to irrelevant information (e.g., background noise) are critical to learning (Baddeley, 2003). As a group, people with LI present with lower levels of mental attention than unaffected peers (Im-Bolter, Johnson, & Pascual-Leone, 2006). Also, in the current study, the students with LI reported more symptoms of ADHD on the CAARS screening test than the students with ND. Moreover, the students' ratings of their attention to the lecture were highly predictive of learning outcomes in both the LI and ND groups, suggesting that attention deficits— as a chronic condition or a momentary lapse— were a barrier to learning from lectures.

While directing attention to new information, the learner holds that information in the phonological loop. Young adults with LI evince limited phonological short-term memory (Poll, Betz, & Miller, 2010), and the students with LI in the current study scored lower than their peers with ND on a measure of phonological short-term memory, non-word repetition. However, nonword repetition scores did not predict learning outcomes for the students with LI or the students with ND. Given that we did find nonword repetition scores to correlate with sentence repetition scores, we do not think that the lack of relationship between nonword repetition and learning outcomes was due to a limited range of nonword repetition scores. Examination of the post-test questions suggests an explanation. The test taps the learning of new facts and word meanings more so than the phonological form of the new words. It is likely that the ability to hold an exact sequence of sounds in the phonological loop is not critical to this sort of learning. Alternatively, it could be that by adulthood, the integrity of the phonological loop is not as critical to verbal learning as it is earlier in development (see Gathercole, Willis, Emslie, and Baddeley, 1992 for an investigation of developmental changes in the relationship between phonological memory and vocabulary acquisition).

If the learner does not integrate new information with existing knowledge, learning is incomplete. Baddeley (2003) posits that an episodic buffer integrates newly processed information with information already in long-or short-term memory. Our measure of the integrity of the episodic buffer, sentence repetition, was predictive of learning outcomes in the LI group, suggesting that a limited ability to integrate information from the short-term store (i.e., new facts and word meanings) and long-term stores (i.e., extant knowledge of words and syntax) could be a barrier to learning from lectures. The current study does not elucidate which aspects of the work done by the episodic buffer are at fault. Riches (2012) found that sentence repetition performance in children with LI was better predicted by a measure of long-term syntactic knowledge than measures of short-term or working memory, leading him to conclude that the primary problem was the integrity of linguistic representations in long-term memory, that is, with syntactic competence.

Sentence repetition did not predict the learning of students with ND. This does not mean that the episodic buffer is irrelevant to their learning; rather, their sentence repetition skills were uniformly strong, so they did not predict variability in learning. Their sentence repetition scores approached ceiling (89%) and variability around the mean was smaller than that in the LI group.

For learning from lectures, the extant vocabulary, the repository of words and their meanings, is a relevant aspect of long-term memory. The richer the vocabulary, the more readily new information can be integrated. The PPVT-IV, our measure of vocabulary, differentiated the LI and ND groups and the PPVT-IV scores correlated with learning performance for both groups. However, in the regression model of learning outcomes in the LI group, the PPVT-IV scores were not significant predictors after the sentence repetition scores were entered. This suggests that limitation in integrating information from short-term and long-term memory was a larger barrier to learning from lectures than any vocabulary limitation per se. An alternative way to think about this is to consider that the PPVT-IV scores of the LI group, while lower than those of the ND group, were still at the normative mean. Other young adults with LI, perhaps those who are unable to attend post-secondary school, may have vocabulary deficits that would impede learning from lectures and other spoken discourse.

4.2 Implications

The scope of practice for school-based speech-language pathologists in the United States includes service to pre-kindergarten, elementary, and secondary students and collaboration with professionals in higher education to meet students' needs in college and university settings (ASHA, 2010). In this paper, we have highlighted a need to be considered in the transition plans for students with LI who will enroll in post-secondary education at colleges and universities, namely, the need to prepare students for learning from the mostly lecture-based format of the post-secondary classroom. As we come closer to finding the underlying mechanisms involved in LI, we can begin to suggest specific strategies for this preparation. The current study does not allow conclusions about causation, but the correlational patterns implicate strategies that support working memory by enhancing attention and facilitating the integration of new and old information.

4.3 Future Directions

The current study provides empirical evidence that college students with LI do not learn as much from spoken lectures as their peers. It is critical to note that this laboratory-based study is the first step and that implications for learning in authentic classroom settings must be validated empirically. It is possible that this laboratory-based study over-estimates the problem given that actual classroom lectures are more likely to build on prior knowledge, and to provide more visual supports and more opportunities for discussion and questions. On the other hand, this study might under-estimate the size of the problem given that learning in actual classroom lectures would involve higher stakes (e.g., grades), more material (e.g., longer lectures), more demands (e.g., listening, watching, reading, and note-taking), and more distractions (e.g., noise).

We must emphasize that the participants in this study responded to questions about the lecture immediately after its delivery; thus, we measured only the initial aspects of learning. This procedure does not reveal the enhanced learning that is possible with review and reflection. A useful next step would be to evaluate learning in a naturalistic college lecture environment. In subsequent work, one might assess the usefulness of different types of note-taking during encoding and different types of review to longer-term outcomes.

5. Conclusions

We conclude that spoken lectures are a challenging learning context for college students with LI; the challenge is revealed on both recognition and recall questions administered immediately after the lecture, and deficits in working memory are associated with the problem. The speech-language pathologists working on transition plans for a college-bound student with LI should consider the student's readiness to meet this challenge.

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APPENDIX

PHILOSOPHY BASELINE TEST

For multiple choice questions, pick the one best answer. For fill-in-the-blanks, you use one or two words that fit best.

1. This area of philosophy pursues questions about the nature of reality, including the relationship between mind and matter:
 - a. realism
 - b. metaphysics
 - c. a posteriori

- d. speculation
2. _____ is the view that knowledge comes from the senses or experience.
3. Rationalism is the view that knowledge comes from:
- a. reason
 - b. emotion
 - c. truth
 - d. nature
4. _____, a rationalist, is considered the father of modern philosophy.
5. David Hume believed that knowledge comes from:
- a. experience
 - b. reason
 - c. skepticism
 - d. morality
6. _____ Evil is a type of evil that is not caused by man (for example, what Hurricane Katrina would be considered).
7. An example of _____ Evil is terrorism. This is directly caused by man.
8. The philosophical problem of evil challenges the notion that god is _____, and thus should be able to stop evil.
9. _____ believed there were no innate ideas – that the mind was a tabula rasa (blank slate) at birth.
- a. Rene Descartes
 - b. Plato
 - c. David Hume
 - d. John Locke
10. _____ is the art and science of textual interpretation.
- a. Phonics
 - b. Logic
 - c. Hermeneutics
 - d. Aesthetics
11. _____ is the study of right and wrong.
12. _____ is the study of correct reasoning.

13. The Law of _____ states that something cannot both be and not be.
- Opposites
 - Non-contradiction
 - Reason
 - Logic
14. _____ is the belief that future events happen regardless of what someone does.
- Absolutism
 - Nihilism
 - Fatalism
 - Passivism
15. While logos appeals to facts and logic, _____ appeals to emotions.
16. A _____ argument uses premises to show that a conclusion is true.
- deductive
 - inductive
 - productive
 - reductive
17. Subjective absolutism is the belief that _____ is a matter of personal preference.
18. _____ is known for his conclusion “cogito ergo sum,” or “I think, therefore I am.”
- Comte
 - Descartes
 - Socrates
 - Marx
19. Kant believed that a person does something moral because there is a/an _____ to do it.
20. According to Hume, a person acts because of _____, which is first motivated by reason.
- logic
 - morality
 - duty
 - passion

PHILOSOPHY LECTURE POSTTEST

SOCRATES ON THE EXAMINED LIFE

For multiple choice questions, pick the one best answer. For fill-in-the-blanks, you use one or two words that fit best.

1. Everything we know from Socrates comes from two sources. The first source is his student _____, and the second source is Xenophon.
2. The Socratic Method is a method of inquiry that tests every assumption for:
 - a. its sources
 - b. its experimental results
 - c. its grounding and implications
 - d. its completeness
3. Socrates described himself as a gadfly. In what way was this so?
 - a. He showed people's beliefs to be groundless through interrogation
 - b. His voice resembled that of a gadfly
 - c. He was hubristic and arrogant
 - d. The Athenian youth respected him
4. In Greek mythology, a gadfly knocked a rider off his horse. The rider was trying to fly to _____.
5. Socrates was well trained in the art of _____.
6. The objective of Socrates was not just to expose the ignorance of an interlocutor but ultimately:
 - a. to train the interlocutor in Sophism
 - b. to learn a new philosophy
 - c. to examine the Sophist way of thinking
 - d. to find truth
7. Sophistical teaching has at its core an _____ form.
 - a. argumentative
 - b. arrogant
 - c. interrogative
 - d. intellectual
8. According to Augustine, the first obligation of a philosopher is the commitment to live and die for _____ of his philosophy.

9. Socrates' friends urged him to _____ after his trial, as it had been a sham.
10. The charges brought against Socrates were that he had failed to respect the gods of Athens, and that he had _____ the youth of Athens.
11. After being found guilty, Socrates was given the choice between death and _____.
12. Why does Socrates choose death?
- He is an atheist
 - He will not break the law
 - He feels the law is unfair
 - Alcibiades convinces him to do so.
13. According to Socrates, the law is reason without:
- passion
 - examination
 - expression
 - interpretation
14. Socratic philosophy includes the idea that "the _____ is not worth living".
15. In Plato's Republic, Socrates discusses:
- brains in vats
 - teachers in a corrupt society
 - prisoners in a cave
 - youth in self-examination
16. Gnothi seauton, translated to English, means _____.
17. According to the lecture, what must be defeated in order to claim there is something we can actually know?
- The state
 - Knowledge
 - The Socratic agenda
 - Skepticism
18. What is the philosophical question/agenda that Socrates and Descartes both had in common?
- What is the examined life?

- b. Is it possible to know anything?
 - c. What kind of beings are we as humans?
 - d. What is the relationship between the individual and the state?
19. The Athenians treasured the _____ character of the polis, or state, though by modern standards we may not think historical Athens had such a state.
20. Socratic philosophy suggests that once we have defeated a skeptical position on knowledge, we can have a defensible position on:
- a. government
 - b. purpose
 - c. ethics
 - d. democracy

PHYSICS BASELINE TEST

For multiple choice questions, pick the one best answer. For fill-in-the-blanks, you use one or two words that fit best.

1. What type of lens is a magnifying glass?
- a. concave
 - b. plane glass
 - c. plano-concave
 - d. convex
2. A freely suspended magnet always aligns itself along the _____ - _____ axis.
3. A _____ is the band of seven colors formed by splitting of light by a prism.
4. The rate of change of a position in a fixed direction is called:
- a. velocity
 - b. acceleration
 - c. momentum
 - d. speed
5. Metals _____ upon heating but _____ upon cooling.
- a. expand/contract
 - b. do not change/contract
 - c. contract/do not change
 - d. contract/expand

6. When a spring is released, its potential energy is converted to _____energy.
7. The idea that “objects in motion remain in motion, whereas objects at rest remain at rest” relates to:
- acceleration
 - motion
 - inertia
 - velocity
8. Speed equals distance divided by _____.
9. A quantity that specifies a magnitude and a direction is called a:
- scalar
 - vector
 - constant
 - wave
10. The force between your feet and the floor is _____while standing on your tiptoes than while standing flat on your feet.
11. A mole of helium has _____ as a mole of lead.
- the same number of molecules
 - more atoms
 - fewer molecules
 - the same number of atoms
12. The amount of energy a sound wave transmits is directly related to the wave’s:
- shape
 - frequency
 - amplitude
 - direction
13. Newton’s Law of Universal Gravitation states that any two masses exert a/an _____force on each other.
14. Density equals _____over volume.
15. The point where all the _____ of an object appears to be concentrated is called its center of gravity.
16. Pressure equals force over _____.
17. Soap bubbles are spherical in shape because:

- a. air trapped inside the bubble has low pressure.
 - b. air exerts equal pressure in all directions.
 - c. soap film has a low surface tension.
 - d. spherical shape has the highest ratio of surface area to volume.
18. In a neutral atom, the number of electrons is equal to the number of _____
19. Rays of light always travel in:
- a. transverse waves
 - b. pairs
 - c. spectra
 - d. straight lines
20. Lightening takes place:
- a. before thunder.
 - b. at the same time as thunder.
 - c. after thunder.
 - d. sometimes before and sometimes after thunder.

PHYSICS LECTURE POSTTEST

ENTER THE QUANTUM.—For multiple choice questions, pick the one best answer. For fill-in-the-blanks, you use one or two words that fit best.

1. Light shining on a metal surface in a vacuum can eject _____ from the metal.
2. What is the name of the effect described in question 1?
 - a. Photomagnetic Effect
 - b. Photoelectric Effect
 - c. Infrared Effect
 - d. Electromagnetic Effect
3. According to classical physics, what property of the light shining on the metal surface should not matter?
 - a. the color
 - b. the amplitude
 - c. the speed
 - d. the intensity

4. Effect X's experimental results are different from what classical physics would predict for four reasons in particular. Which of the following was NOT one of these reasons predicted by classical physics?
- Atoms should emit light of all colors.
 - Hot objects should glow with ultraviolet light
 - Atoms should emit electricity regardless of light
 - Effect X should take a long time, independently of color.
5. Max Plank (1900) posited that atomic vibrations are _____, occurring in multiples of a certain basic amount.
6. This amount was given the variable h and is now known as "Plank's _____."
7. How big is h ?
- 10^{-3}
 - 10^3
 - 10^{33}
 - 10^{-33}
8. If h were 0, the universe would be:
- discontinuous
 - continuous
 - relative
 - unquantifiable
9. The formula for the required basic amount of vibrations is $E=hf$. E is _____.
10. The formula for the required basic amount of vibrations is $E=hf$. f is _____.
11. Einstein declared that the energy in a light wave is concentrated in particle-like bundles called:
- Photons
 - Atoms
 - Quantums
 - Spectra
12. Einstein explains that if a light wave has too low of a frequency, the _____ will be too low for Effect X to take place.
13. For Effect X to take place, light must have more of the color:

- a. Red
 - b. Yellow
 - c. Blue
 - d. Infrared
14. Due to the fact that light particles are bundled, when the light frequency is high enough:
- a. Ejection occurs in accordance with the energy omitted
 - b. Ejection cannot occur
 - c. Ejection occurs gradually
 - d. Ejection occurs immediately
15. How many of these light bundles must hit an electron for Effect X to occur?

16. In 1913, Niels Bohr proposed the Bohr model of the atom, which indicated that atomic orbits are _____, with only certain discrete orbits allowed.
17. The discrete orbits that are allowed correspond to discrete values of:
- a. electricity emitted
 - b. the electrons' energy
 - c. the frequency of the light
 - d. color spectra
18. Atoms radiate _____ waves only when electrons jump among orbits.
19. When atoms jump among orbits, they emit a specific _____ of light.
20. Effect X explains the relationship between:
- a. Electricity and magnetism
 - b. Color and light
 - c. Light and electricity
 - d. Magnetism and light

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Highlights

Students with developmental language impairment are increasingly represented on college campuses.

Students who have developmental language impairment learned less from listening to a college lecture than their unaffected peers.

The learning problem of students with developmental language impairment was evident on both multiple choice and fill-in-the-blank test questions.

Within the group of students with developmental language impairment, poorer learning outcomes were associated with lower scores on two measures of working memory: attention and sentence repetition.

Figure 1. Post-test performance by question type, topic, and participant group (ND in grey; LI in white). Error bars indicate standard errors.

Figure 2.
Post-test performance by participant group and topic.

Table 1.

Comparison of mean test scores (M) and standard deviations (SD) as well as minimum (Min) and maximum (Max) test scores for ND and LI groups.

Domain	Test		ND group	LI group	Effect size d for group comparisons
Inclusionary/exclusionary measures					
Spelling	Fidler et al. (2011)	M	80%	37%	1.6
		SD	34%	17%	
		Min	40%	7%	
		Max	100%	80%	
Language Comprehension	Modified Token Test (Fidler et al., 2011)	M	93%	81%	1.5
		SD	5%	10%	
		Min	80%	55%	
		Max	100%	98%	
Descriptive measures					
Receptive Vocabulary	PPVT-IV	M	117	102	1.2
		SD	11.9	12.1	
		Min	96	80	
		Max	137	126	
Expressive Vocabulary	EVT	M	120	107	1.1
		SD	10.6	12.6	
		Min	92	75	
		Max	146	126	
Word Definition	CELF-3 Definition Subtest	M	14.18	12.71	.95
		SD	1.1	1.9	
		Min	12	9	
		Max	16	16	
Sentence Repetition	CELF-3 Recalling Sentences	M	89%	78%	1.2
		SD	7%	11%	
		Min	67%	45%	
		Max	100%	96%	
Phonological Memory	Nonword Repetition Probe from Dollaghan & Campbell (1998)	M	94%	91%	.85
		SD	3%	4%	
		Min	86%	79%	
		Max	99%	99%	
Attention	CAARS-ADHD symptoms	M	51	60	−.43
		SD	10	28	
		Min	35	33	
		Max	72	90	
Nonverbal IQ	KBIT	M	110	106	n.s.
		SD	10.7	12.5	
		Min	94	85	

Domain	Test	ND group	LI group	Effect size d for group comparisons
		Max	132	130

Note. Scores on the probes of spelling, language comprehension, sentence recall, and nonword repetition are the percentage of items correct. On the spelling probe, a perfect score would be 15/15; on the language comprehension probe, a perfect score would be 44/44; on the sentence recall probe, a perfect score would be 78/78; and on the nonword repetition probe, a perfect score would be 96/96. Scores on the Peabody Pictures Vocabulary Test 4th edition (PPVT-IV), Expressive Vocabulary Test (EVT), and Kaufman Brief Intelligence Test nonverbal subtest (KBIT) are standard scores with a normative mean of 100 and a standard deviation of 15. Scores on the Word Definition subtest of the Clinical Evaluation of Language Fundamentals are standard scores with a normative mean of 10 and a standard deviation of 3. Scores on the Conners' Adult ADHD Rating Scales (CAARS-ADHD) are t scores with a normative mean of 50 and a standard deviation of 10 (higher scores indicate greater attention deficits). All between-group differences are significant at $p < .02$ with one exception indicated.