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What do college students with learning disabilities learn from lectures?

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WHAT DO COLLEGE STUDENTS WITH LEARNING DISABILITIES LEARN FROM LECTURES?

by

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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has been approved by the Examining Committee for the thesis requirement for the Master of Arts degree in Speech Pathology and Audiology at the May 2015 graduation.

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ABSTRACT

A learning disability (LD) is any disability resulting from a primary impairment in comprehending or expressing language. Many studies have looked at atypical language processes in children – particularly those with specific language impairment and dyslexia – but few have considered to how language demands, and therefore the impact of LD, change as children or adolescents transition into the postsecondary setting where auditory language abilities are often a necessary component for success.

In this study we posited that students with LD would have a more difficult time learning information from a typical lecture format, and that contributors such as extant vocabulary, short-term verbal memory, and attention would all predict outcomes for post-lecture test performance. Participants were 34 college students with LD and 34 college students who were typically developing (ND). Each participant watched a 30-minute lecture. Before the lecture, a baseline-test of general topic knowledge was given. Afterwards a post-test was given regarding specific information from the lecture. Additionally, multiple standardized tests and ratings were given to each participant to assess individual differences that contributed to outcomes on the post-test. We found that LD students learned less information from the lecture than did the ND students. Student performance on vocabulary and attention measures predicted post-test performance, and verbal memory was an additional predictor for LD participants.

PUBLIC ABSTRACT

Individuals with learning disabilities make up an important demographic on college campuses. According to the Individuals with Disabilities Act (2004), learning disability is characterized by a difficulty with language. As such, typical college lectures are expected to be challenging for these students. We suggest that this difficulty involves an interaction of multiple factors, including attention and auditory memory – both of which affect word-learning. We predict that college students with learning disabilities will have more difficulty than typically-developing peers when learning from a lecture with minimal supports accompanying spoken language (like visual aids or note-taking).

Participants in this study included 34 college students with learning disabilities (LD) and 34 college students who were typically developing (ND). Each individual watched a 30-minute lecture over a common college topic. Before the lecture, a test of general topic knowledge was given, and afterwards a post-test was given regarding specific information from the lecture. LD students learned less information from the lecture than did the ND students. Student performance on vocabulary and attention measures predicted post-test performance. Additionally, verbal memory was a predictor for LD participants. These data suggest that there is a complex interaction between multiple cognitive processes, and our ability to learn new words and information from lectures. This interaction is particularly influential in students with LD, and should be further studied to find appropriate compensatory strategies and accommodations for college students with learning disabilities.

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CHAPTER I: INTRODUCTION AND REVIEW OF THE LITERATURE

Achieving a post-secondary education is undoubtedly one of the most challenging – and potentially rewarding – tasks that many students face as they transition from high-school into a future career. Students with learning disabilities who attend college often have challenges surpassing those of typical learners. This review of the literature aims to explore the background of learning disabilities, including current legislation and typical post-secondary student outcomes, as well as exploring specific obstacles, both internal and external, that that college students face in post-secondary education.

What is a Learning Disability?

"Learning Disability" (LD) is an umbrella term for a relatively large set of neurological pathologies that often affect attention, language, and memory. The term LD is sometimes used interchangeably with others such as "Language Impairment," or "Language and Learning Disorders," although, in the strictest sense of each term, there are subtle differences. The most common LD is Specific Reading Disorder (SRD) (commonly referred to as Dyslexia). There is debate about the relationship between specific language impairment (commonly diagnosed on the basis of spoken language deficits) and SRD. Many more individuals have both diagnoses than would be predicted on the basis of strict co-morbidity but the two diagnoses do not always co-occur (McArthur, Hogben, Edwards, Heath, & Mengler, 2000). Therefore, specific language impairment is often considered a risk factor for SRD or for LDs in general (Plante, Van Petten, & Senkfor, 2000). Additionally, while they are not learning disabilities under the

Individuals with Disabilities Education Act (IDEA) of 2004, Autism and Attention Deficit Hyperactivity Disorder (ADHD) also have qualities that affect learning capabilities, and share high rates of comorbidity with learning disabilities. The Center for Learning Disabilities defines LD as a disorder affecting the ability of the brain to "receive, process, store and respond to information." In this definition, language impairment is not inherently assumed, as information can be received (and later processed, stored, and responded to) nonverbally; however, according to IDEA, language pathology – a deficit in understanding or using language – is the primary factor in identification of individuals with learning disabilities. Students with LD show primary deficits in one or any combination of the following: written language expression, oral language expression, written comprehension, oral comprehension, and mathematic calculation.

Access to Post-Secondary Education

With the introduction of Section 504 of the Rehabilitation Act (1973) and more recently the Individuals with Disabilities Education Act (IDEA 2004) and the Americans with Disabilities Act Amendments Act (ADAAA 2004), an increasing number of students with disabilities – many with LD – have been given greater access to post-secondary education. Under these laws, students with disabilities, whether physical or communicative, are ensured equal access in federally funded education agencies. Under IDEA (2004), not only are education agencies obligated to provide Free and Appropriate Public Education through the age of 21 at the secondary level, but they must also provide students with preparation for their future as independent adults, and continue to offer accommodations in post-secondary schools and in the workplace. According to the

National Longitudinal Transition Study, conducted by the US Department of Education, 60% of students with disabilities go on to study at colleges and universities.

Students with LD in College: Outcomes and Accommodations

Students with LD make up 29% of the total number of college students with disabilities. Newman et al. (2011) report that a high percentage of LD students who begin college do not graduate. These students show much lower rates of persistence and degree attainment in post-secondary institutions than normally developing (ND) students (Horn, Berktold, & Bobbitt, 1999), as well as increased risk for unemployment after completing their education (Newman et al., 2011). Currie (2001) suggests that investing in proper accommodations for students who need them – thus encouraging college success – will ultimately allow the government to reap long-term benefits from their investment. Typical college accommodations for LD students, as taken from the Student Disability Services website at the University of Iowa, are of two types, exam services and media services. Exam services include extended time, low-distraction testing environment, audio format, and use of a scribe or word processer. Media services involve alternatives to print so that people unable or less able to read print can access classroom materials. At some universities, foreign language requirements are waived as well (Fiddler, Plante, & Vance, 2011; Skinner & Smith, 2011); however, this accommodation does not address the inherent problem of learning language, be it foreign or native.

Under IDEA (2004), to receive accommodations in the post-secondary institutions, students must voluntarily disclose their disability. Newman et al. estimate that only 28% of these students who were previously identified disclose at the post-secondary level, and of those students, only 19% receive accommodations for their disability. Additionally, diagnostic criteria for LD students in post-secondary institutions are lacking (Sparks & Lovett, 2009) and the process for proving to the college one's inclusion in this diagnostic group– including but not limited to receiving standardized testing in the state of one's institution – can be complicated, time-consuming, and costly.

College Lecture Format

Unlike most high schools, many college and university classes are comprised of large numbers of students, and relatively less individual support. This is often a time when students leave their homes and become completely independent in their own studies – having to organize and manage their own learning experiences. Additionally, at larger public universities, classes are generally presented in lecture format to a large group of students, presenting new challenges for LD students who now must learn to compensate for their disability and become advocates for themselves with regards to their education. While accommodations generally allow for individualized settings for testing, they do not necessarily facilitate learning in the lecture format. In fact, media accommodations are aimed at alternatives to print. The unspoken assumption is that students with LD do not need accommodations to access spoken information. But spoken lectures might well be challenging for students with LD. The visual aids that sometimes accompany these lectures are generated with a typical learning population in mind (i.e., they are text-heavy) and classroom distractions are common – both those imposed by others (e.g., noise from other students) and self (e.g., use of Facebook in class). Moreover, there is compelling evidence that LD involves compromised verbal learning in any modality, written or spoken. In the next sections, we summarize this evidence.

Mechanisms of LD

Word Learning and Vocabulary

One manifestation of LD that persists across development is difficulty with word learning (Elbert, 1984; Munson, Kurtz, & Windsor, 2005; Carlisle, Fleming, & Gudbrandsen, 2000; McGregor et al., 2013). In a longitudinal study, McGregor, Oleson, Bahnsen and Duff (2013) examined the breadth and depth of vocabulary knowledge in 177 children with developmental language impairment and 325 ND school-aged children between grades 2 and 8. The children with language impairment were behind their ND peers in both breadth (how many words they know) and depth (how well they know words), as measured in a word-definition task. The deficit was found to persist throughout the school years. This deficit could be the result of poor reading abilities and, in the later school years, poor reading likely contributed. But its presence at grade 2 speaks against learning from the written modality as the only obstacle. Empirical evidence reveals that the oral modality is an obstacle as well. McGregor, Licandro, Arenas, Eden, Stiles, et al. (2013) demonstrated that word learning from the spoken modality is a challenge for individuals with LD. These were college students with LD who attempted to learn 16 novel word forms and their meanings. Although the meanings were presented as visual referents (line drawings), the word forms were spoken, never written, immediately after training, the students with LD recalled 33% fewer word forms than their ND peers. Moreover, the word form performance of the students with LD was positively correlated with their Token Test scores, a measure of verbal short term memory, and their Peabody Picture Vocabulary Test scores, a measure of extant receptive vocabulary.

Literacy Development

Word learning deficits in children with language impairment/LD may snowball over the course of development. Stanovich (1986, 2000) describes the notion of the rich getting richer and the poor getting poorer with regards to language learning and dubs this phenomenon the "Matthew Effect." LD learners have trouble learning new words, which causes them to have smaller vocabularies relative to their ND peers who continue to develop the depth and breadth of their vocabulary size as they progress through school. This can exacerbate any problems these children might have in learning to read and-or reading for comprehension as a function of the close, reciprocal relationship between language and literacy development. Moreover, because people learn words as they read, the reading deficit can further exacerbate the vocabulary problem. Highly practiced readers will have stronger representations of words in their semantic networks. In a longitudinal study of 485 children, Duff, Tomblin and Catts (2014) explored Matthew effects of strong, average and poor readers with regard to vocabulary size. They found a large effect between word reading skill and vocabulary, but the effect was one-sided, as opposed to the two-sided effect described in Stanovich's (1986, 2000) model. Duff et al. described a large difference between strong and average readers, but not between the average and poor readers, reflecting that in this particular study, the "rich" are indeed getting richer, but the "poor" aren't necessarily getting poorer. Other studies, such as Morgan, Farkas and Hibel (2008) found a one-sided effect in the opposite direction, with LI students falling further behind peers while ND students maintained steady growth.

Memory

There is a general consensus among researchers that memory problems appear to be at the root of LD, though not all agree on the exact process or level of memory that is affected. In a 2006 publication entitled Sleep, Memory and Plasticity, Walker and Stickgold define three subsystems of memory: encoding, consolidation and retrieval. Encoding is the process of acquiring information and entering it into long-term memory. Formation of a new memory is achieved, according to Walker and Stickgold, by engaging with an object or performing an action. This initial engagement forms, or encodes, a representation in the brain, which is later fortified through consolidation (the stabilization of memory over time). It can then be retrieved, which may lead to re-encoding and reconsolidation, as is shown in Figure 1. Fast-mapping, the process of creating an initial representation after few exposures to a referent and can be included under Walker and Stickgold's encoding stage. Slow-mapping, which is the process of strengthening an existing representation with more exposure, can be included under the re-encoding stage. Both fast- and slow-mapping are important to word-learning.

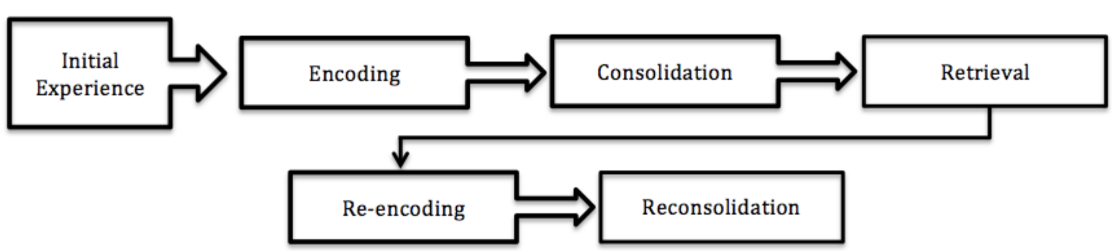

Figure 1. Model of memory processes as described by Walter and Stickgold (2006)

Baddley (2000) offers an additional view of memory, taking into account attention's affect on short-term or working memory, as shown in Figure 2. This model serves as further breakdown of the encoding stage of Walter and Stickgold's model. In order for an individual to encode new information, attention must first be assigned to the relevant information (e.g., a new word), and irrelevant information (e.g., background noise) must be inhibited. Once attention has been assigned, the information continues to be processed in what Baddley refers to as working memory. Working memory consists of a phonological loop for processing verbal information, a visuospatial sketchpad for processing visual information, and an episodic buffer that integrates newly processed information with information already in long- or short-term memory.

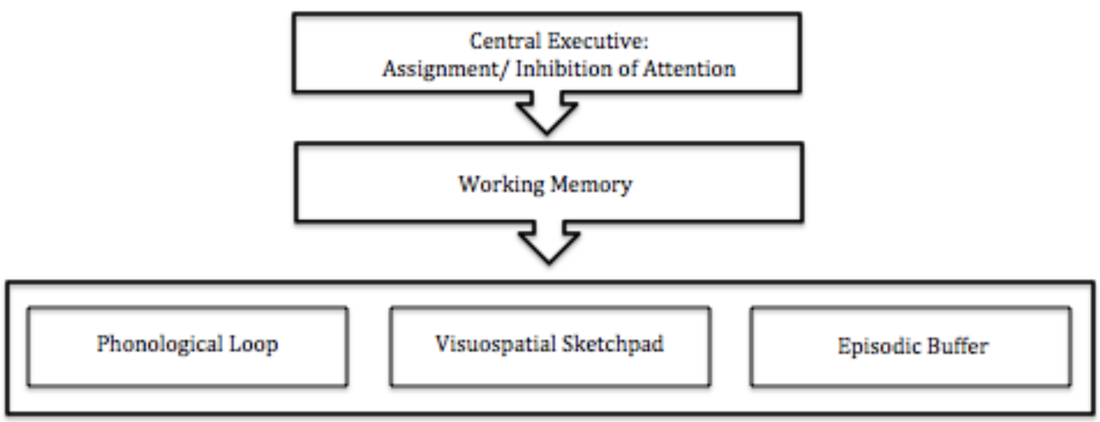

Figure 2. Model of short-term memory by Baddley (2000)

Isaki and Plante (1997) tested verbal memory during the encoding stage in two groups of college students, one with a history of LD and one without. Verbal memory was tested with a sentence repetition task that measured short-term memory in the auditory modality and a reading span task that tested working memory in the visual modality. The students with LD were poorer than their peers on both tasks. McGregor et al. (2013) found college students with LD learn fewer word forms in response to a spoken and written training experience than their ND peers. McGregor, Arbisi-Kelm, and Eden (2014), replicated that finding with an auditory only training and went on to examine retention one week after training. The gap in word form performance between the LD and ND groups remained stable, leading to the conclusions that the encoding of information into long-term memory was deficient but the consolidation stage was intact. Together the studies from the Plante and McGregor laboratories demonstrate that college students with LD have difficulty encoding verbal information from the auditory modality. They do not reveal which mechanisms of encoding are affected but, consistent with the time-sensitive model of memory development in Walker and Stickgold (2006), they do reveal that the encoding stage is the point of breakdown.

To find the mechanisms involved within the encoding stage of verbal learning, we refer back to Baddley's short-term model of memory (2000). With the understanding that the proposed phonological loop accounts for processing incoming auditory information during the encoding stage before it is committed to memory, we suggest that this is a significant contributor to difficulties that students with LD experience, particularly with regards to auditory learning.

The Current Study

The purpose of the current study was to explore the difficulties that LD students encounter in a post-secondary institution during a typical lecture setting presented solely in an auditory modality. The approach was to compare post-lecture performance in two groups, college students with LD and those with ND under the hypothesis that auditory word learning – the committing of verbal information presented in auditory format from short-term to long-term memory – is a particular weakness of students with LD. We expected that students with LD would be less able than peers to answer comprehension questions based on a lecture with minimal visual supports – a type of lecture that is often encountered in typical college classrooms. Because we were interested in what the students learned from the lecture, we also administered a test of baseline knowledge prior to the lecture so that we could factor out any differences in baseline knowledge statistically. Because we were interested in the relationship between learning words from the auditory modality and the status of extant vocabulary knowledge, we correlated post-lecture performance to a standardized vocabulary composite. A secondary question concerned the response format of the test. Prior research (McGregor et al., 2013, 2014) showed that the learning deficit in individuals with LD can be tapped in both expressive and receptive recognition formats, but that the former format is more sensitive. Therefore, we predicted that the students with LD would perform markedly more poorly on fill-in-the-blank questions than on multiple-choice questions than their ND peers (whom we also expect to perform more poorly on fill-in-the-blank, but to a lesser extent, as fill-in-the-blank questions are inherently more difficult than multiple choice ones). Finally, as a preliminary step towards determining which mechanisms of encoding might be deficient, we explored the contribution of attention and short-term verbal memory to post-test performance. Our specific research questions to be answered in this study were the following:

- Do LD students learn auditorily presented material more poorly than ND students?

- Does amount of learning correlate with extant vocabulary?
- Do LD students differ from ND students in their ability to answer recall versus recognition questions?
- Does amount of learning correlate with measures of attention and verbal short-term memory?

CHAPTER II: METHODOLOGY

Participants

Experimental participants were 68 college students from the United States with ages ranging from 18-25 years. These participants were a subgroup of a larger study of college students with LD that is currently in progress from Karla McGregor's word-learning lab at the University of Iowa. Of the 68 participants, 34 had a history of LD diagnosis and 34 had no current or previous diagnosis. LD and ND subjects were matched for age, gender and college. It should be noted that, with the subjects having been recruited through colleges, the reported learning disabilities were not expected to be severe. Participants were classified based on self-report of diagnoses and three measures were used to verify classification of LD, derived from the battery of weighted standardized tests suggested for LD classification by Fidler et al. (2011): a 15-Word Spelling test, the Modified Token Test and the Word Definitions task from the CELF-4. A participant with a positive composite score of the weighted measures as considered LD, as this identified language deficits in both receptive and expressive domains of language as compared to ND participants. Table 1 shows the weights to be used for each test, as suggested by Fidler et al.

In addition to the tasks described above, the participants completed a battery of standardized assessments, including the Kaufman Brief Intelligence Test – 2nd Edition (KBIT), the Peabody Picture Vocabulary Test – 4th Edition (PPVT), the Expressive Vocabulary Test – 2nd Edition (EVT), and the Conners' Adult ADHD Rating Scale – Self Report – Screening Version (CAARS-S:SV). Results of these tests, as well as a post-task self-rating of attention, are reflected in Table 2.

Learning Disabled		History–SLS	Parents--SLI	Groups Combined
	(sensitivity= 78%, specificity= 83%)	sensitivity= 80%, Specificity=87%	sensitivity=63%, specificity=77%	sensitivity=75%, specificity=81%
Variables	**Weight**	**weight**	**weight**	**weight**
constant	6.6626	6.709	6.934	6.711
15-Wd Spelling	-0.2288*	-0.2551*		-0.1107*
CELF4-WD [a]	-0.1475*		-0.1578	-0.1107*
Modified Token	-0.0893*	-0.1283*	-0.1395*	-0.1151*

Table 1. Weighted scores of 3-test battery for LD classification (Fiddler et al. (2011))

Domain	Test		ND n=35	LD n=35
Nonverbal IQ	KBIT	Mean Range	109.85 94-132	105.56 85-130
Spelling	Fiddler, Plante, Vance (2011)	Mean Range	12.06 6-15	5.5 1-12
Language Comprehension	Modified Token Test	Mean Range	40.74 35-44	35.79 24-43
Word Definition	CELF-4 WD Subtest	Mean Range	14.18 12-16	12.71 9-16
Receptive Vocabulary	PPVT	Mean Range	117.41 96-137	101.71 80-126
Expressive Vocabulary	EVT	Mean Range	119.88 92-146	106.88 75-126
ADHD Screen	CAARS-S:SV	Mean Range	39.88 (n=26) 18-75	52.25 (n=28) 7-111
Verbal Short-Term Memory	Non-Word Repetition	Mean Range	90.7 83-95	87.78 76-95
	Modified Token Test	Mean Range	40.74 35-44	35.79 24-43
	Sentence Repetition	Mean Range	69.15 52-78	60.62 35-75
Attention to Lecture	Post-Lecture Attention Rating	Mean Range	4.58 (n=13) 1-6.5	3.51 (n=17) 1.3-7

Table 2. Assessment means and ranges for ND and LD participants

Forty control participants were also included in the study. These participants were undergraduate college students recruited from an introductory course in the Department of Communication Sciences and Disorders (Introduction to Speech and Hearing Processes and Disorders), in which 82 students were enrolled. The examiner invited all students in the course to participate in the study, and 40 agreed. Each control participant took both of the philosophy and physics post-tests without viewing the lecture. This was done to rule out the possibility that ND learners were simply better guessers on the post-test or that they had significantly better general knowledge than the LD learners, ensuring that post-test captured learning of new information from the lecture. If the answers to the post-test were 1) highly predictable or 2) easily answered based on general knowledge, we would expect that the control group would perform nearly as well as the experimental groups. However, we predict the opposite: that the control group will perform significantly lower than either group, and if that is so, we can conclude that performance of the experimental groups reflects learning from the specific lecture.

Tasks

At the beginning of the testing session, each participant was interviewed by an examiner regarding their academic experience and personal familiarity with the topics of Physics and Philosophy, as well as study habits they employ at the college. The interview questions appear in the Appendix. Given the results of the interview regarding familiarity with the two topics, participants were assigned to watch a lecture regarding the topic with which they had the least familiarity. Protocol included that if the participants were equally familiar with both topics, they were randomly assigned to a lecture. However, each participant showed preference, in terms of comfort and experience, for one of the two topics and random assignment was not implemented.

A baseline test over the assigned topic, Physics or Philosophy, was given prior to watching the lecture. The information presented in the baseline test is what we expected students to have been exposed to in an introductory course, and did not cover any specific information from the lecture they were assigned to watch. It consisted of 10 multiple-choice questions and 10 fill-in-the blank questions. The test questions for the baseline test were developed by gathering information from textbooks, presentations and class notes covering broad knowledge as presented in introductory courses of each topic. The baseline test appears in the Appendix.

Participants then watched a 30-minute lecture regarding their assigned topic. Both lectures came from The Great Courses (The Teaching Company) DVD series: “Socrates on the Examined Life” (from The Great Ideas of Philosophy) and “Enter the Quantum” (from Physics and Our Universe: How It All Works). These lectures were chosen because of their similarity, in both content and presentation, to what students may encounter in college classrooms. Both lectures had minimal visual supports, allowing the examiners to capture verbal learning alone, without potential visual contributions. Visual supports in the philosophy lecture included 2 texts of philosophical quotes in Latin and English, 8 short texts of 3 or fewer words, and 4 visual depictions (paintings and sculptures) that accompanied the short texts. Visual supports in the physics lecture included 2 diagrams (one of which was shown twice, the second time with increased complexity), 2 short texts of 3 or fewer words, 2 photos that accompanied the short texts, and 1 equation with labels and definitions (shown 5 times, each time with increased complexity).

Following the lecture, participants were asked to rate their attention to the lecture on a scale of 1 – 7; 7 being very attentive and 1 being not attentive at all. This self-rating was administered between the lecture and the post-test to eliminate bias if the participants felt they were performing poorly on the post-test after they had begun. Participants were assured that any answer on their attention rating was acceptable, as to encourage them to be honest and accurate even if they were not paying attention to the lecture.

The post-test that covered the information presented in the lecture was then given to the participants. Questions for the post-test were developed directly from the lectures presented, and did not inquire about broad or basic topics in physics or philosophy. Each test consisted of 20 questions - 10 multiple choice and 10 fill in the blank. To determine the suitability of these questions, a pilot study of 8 ND learners was performed. Four watched the philosophy lecture and four watched the physics lecture. Scores ranged from 9 to 19 (out of 20), thus providing evidence that the questions elicited neither floor nor ceiling-level performance. The post-test questions appear in the Appendix. A review of all tasks is included in Figure 3.

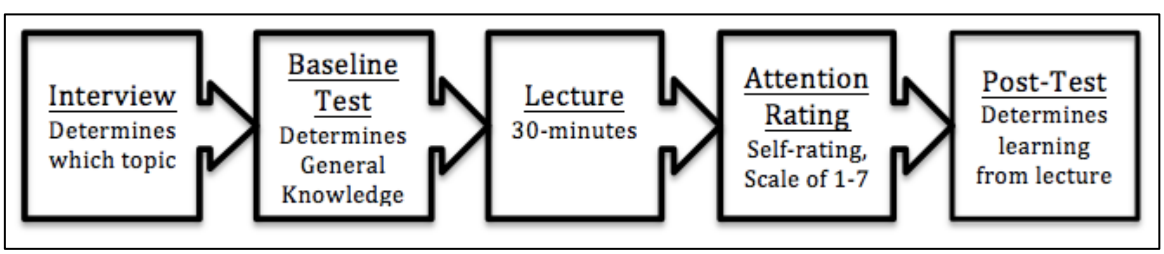

Figure 3. Review of experimental tasks

CHAPTER III: RESULTS

As a preliminary step, we compared baseline performance by group and topic to determine whether or not the two groups presented with similar baseline knowledge and whether the topics were similarly difficult. For multiple choice questions, an ANOVA with group and topic as between-subject factors, revealed a marginal difference in performance by topic (philosophy mean=.42 with SE=.03, physics mean=.50 with SE=.03, $F(1,64)=3.50$, df=1, $p=.065$ partial $\eta^2=.05$), but no significant group differences (ND mean=.49 with SE=.03, LD mean=.43 with SE=.03, $F(1,64)=1.35$, df=1, $p=.25$). However, on fill-in-the-blank questions, there was a significant topic difference (philosophy mean=.22 with SE=.03, physics mean=.42 with SE=.04, $F(1,64)=15.81$, df=1, $p=.0002$, partial $\eta^2=.2$) as well as a significant group difference (ND mean=.40 with SE=.04, LD mean=.23 with SE=.04, $F(1,64)=11.73$, df=1, $p=.001$, partial $\eta^2=.15$). Given the difference between topics, we retained topic as a factor in subsequent analyses.

Our primary question was whether or not the ND group learned more from the lecture than the LD group, as measured on the post-test. This was analyzed through Analyses of Covariance (ANCOVA) with group and topic as between-subjects factors and baseline performance as a covariate, given that the ND group and the LD group came into the study with different baseline performances. The results are depicted in Figure 4. For multiple choice questions, there was a main effect of group (ND mean=.73 with SE=.03, LD mean=.55 with SE=.03, $F(1,63)=15.57$, df=1, $p=.0002$, partial $\eta^2=.2$) but no effect of topic ($F=1.65$, df=1, $p=.2$). For fill-in-the-blank questions, there was also a main effect of group (ND mean=.67 with SE=.03, LD mean=.46 with SE=.03, $F(1,63)=10.99$, df=1, $p=.002$, partial $\eta^2=.15$) but again, no effect of topic ($F=.09$, df=1, $p=.77$).

Additionally, for the fill-in-the-blank questions, there was a significant effect of covariate, showing that fill-in-the-blank performance at post-test was related to fill-in-the-blank performance at baseline. We anticipated this group effect, particularly on fill-in-the-blank questions, which is why we chose to use a covariate to analyze post-test performance.

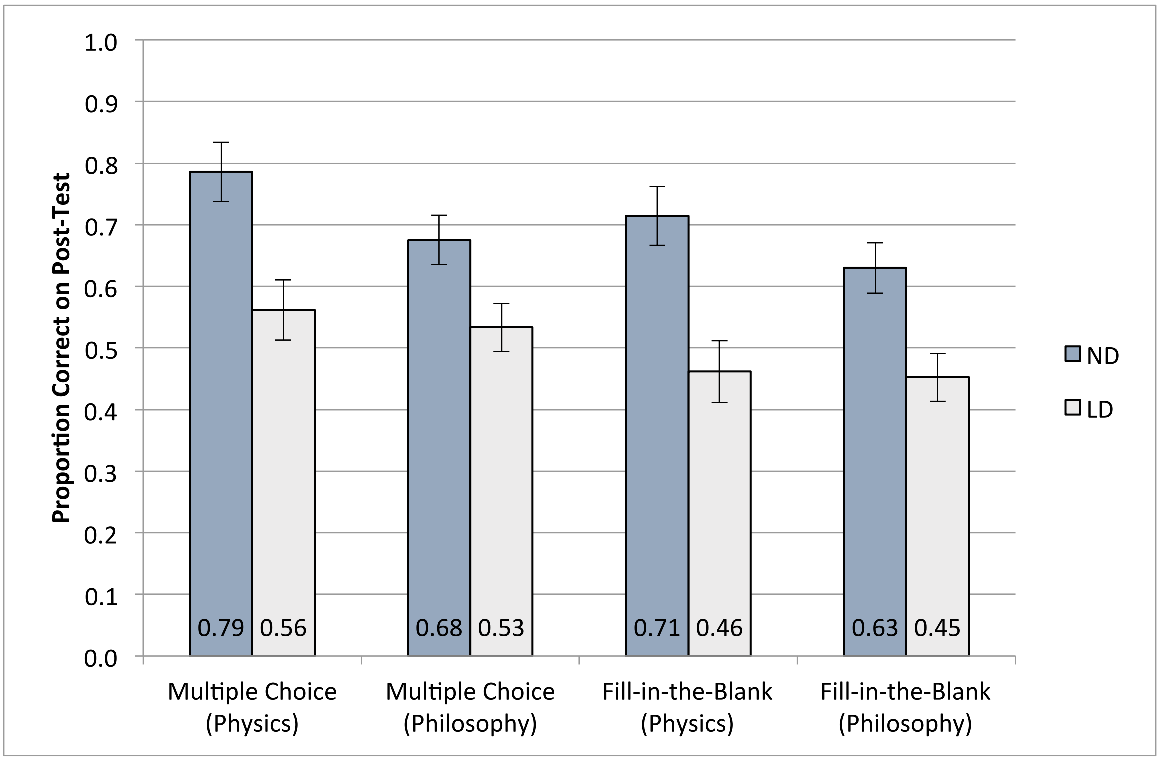

Figure 4. Post-test performance for ND and LD groups

To ensure that the ND-LD difference was one of learning from lecture rather than good test taking skills, we compared performance measures from the 40 control participants to all experimental participants. Recall that all the control participants had to go on was their ability to make wise guesses and any pre-existing knowledge of the topic;

they did not hear the lecture. Control group performance was significantly lower than experimental groups' performance on both multiple choice and fill-in-the-blank questions ($F=253.03$, $p=.000$, partial $\eta^2=.78$ and $F=239.19$, $p=.000$, partial $\eta^2=.77$ respectively), as shown in Figure 5. No effect of topic was found when comparing control versus experimental groups.

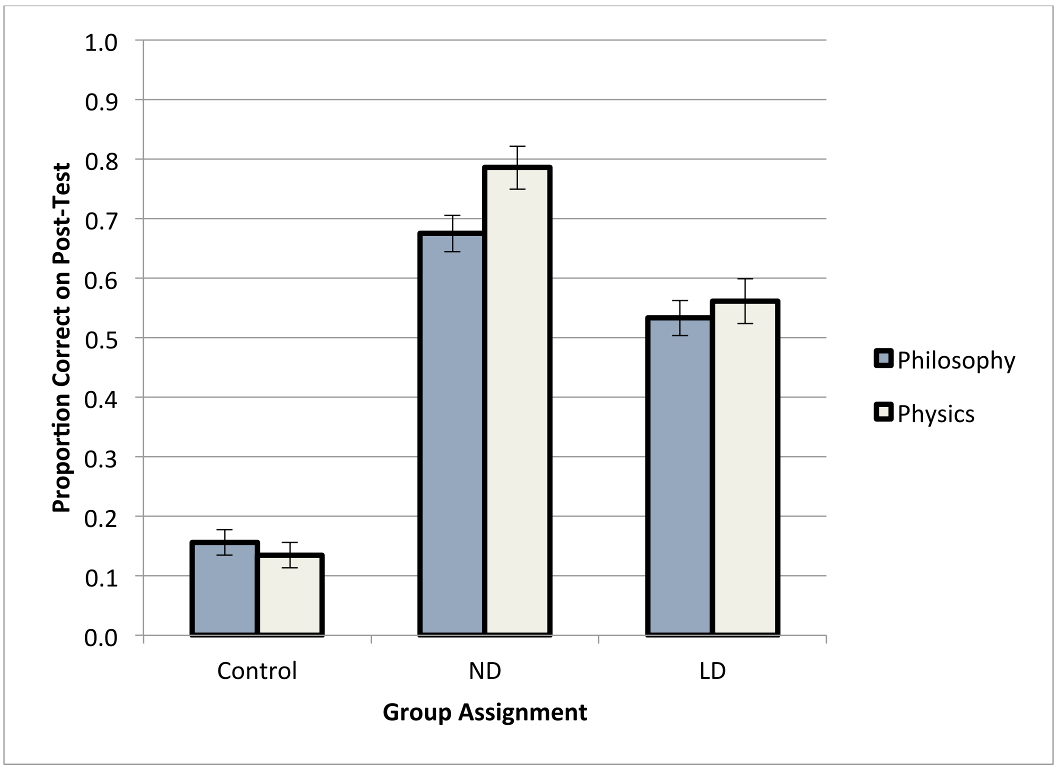

Figure 5. Control performance on post-test

Further analyses were performed to look at individual variation of the participants. Correlations between standardized assessments and post-test performance were calculated. To reduce the number of correlations tested, we formed a vocabulary composite by combining standard scores of the PPVT and the EVT and dividing by 2. For both ND and LD groups, post-test performance showed a significant correlation with vocabulary composite scores, (r=.49, p=.003 and r=.44, p=.001 respectively). Correlations are shown in Figure 6 and Figure 7.

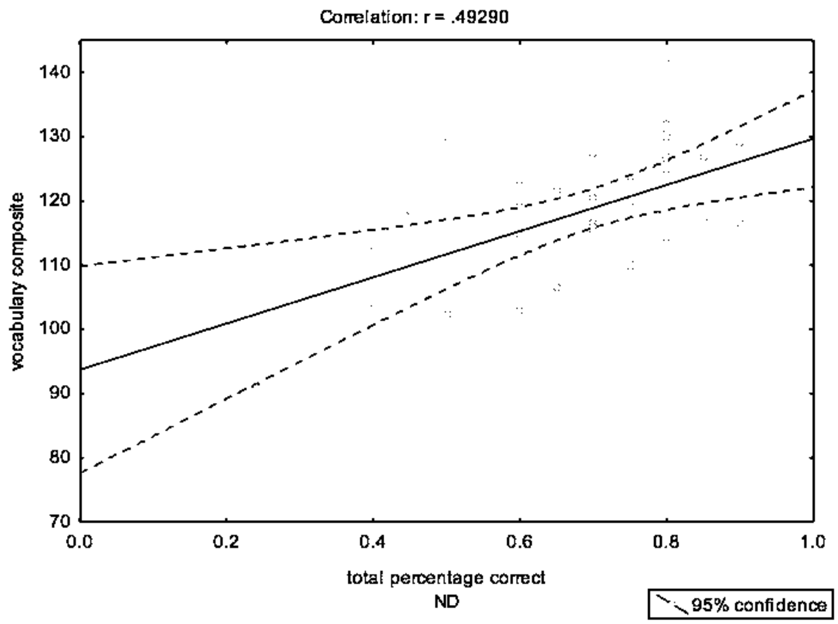

Figure 6. Vocabulary predicts learning for ND students

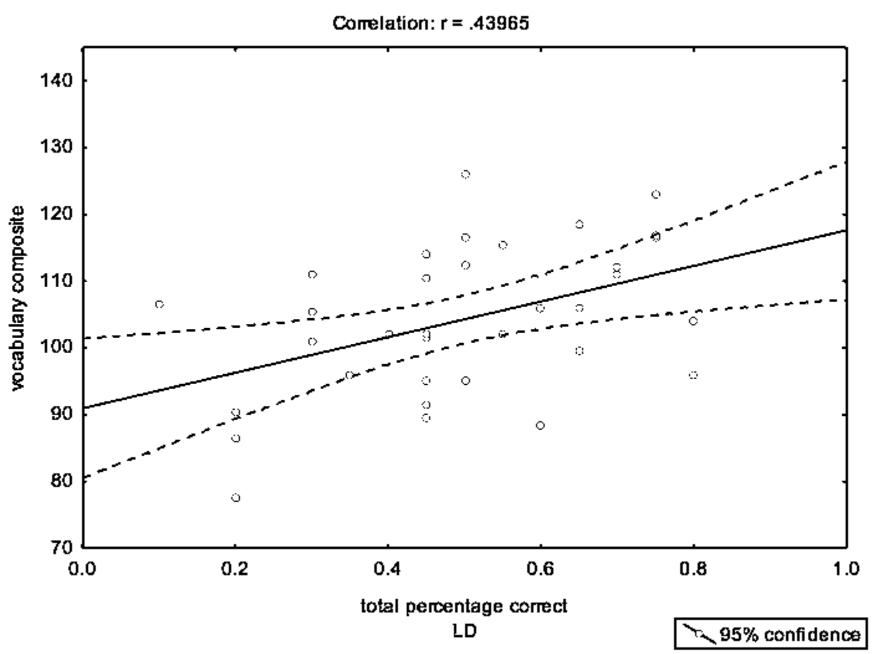

Figure 7. Vocabulary predicts learning for LD students

Additionally, for students with LD, post-test performance correlated with verbal memory scores (r=.52, p=.02), as measured by a composite of percentage items correct on the sentence repetition, token test, and non-word repetition divided by three. No such correlation was found for ND students. This is shown in Figure 8. A review of Table 2 gives insight into why vocabulary, but not verbal learning, predicts performance in ND learners. To attain a significant correlation there must be a larger range and variability of scores. Our ND group had a relatively small range of variability in its scores for verbal learning, therefore not achieving the sensitivity necessary for correlation.

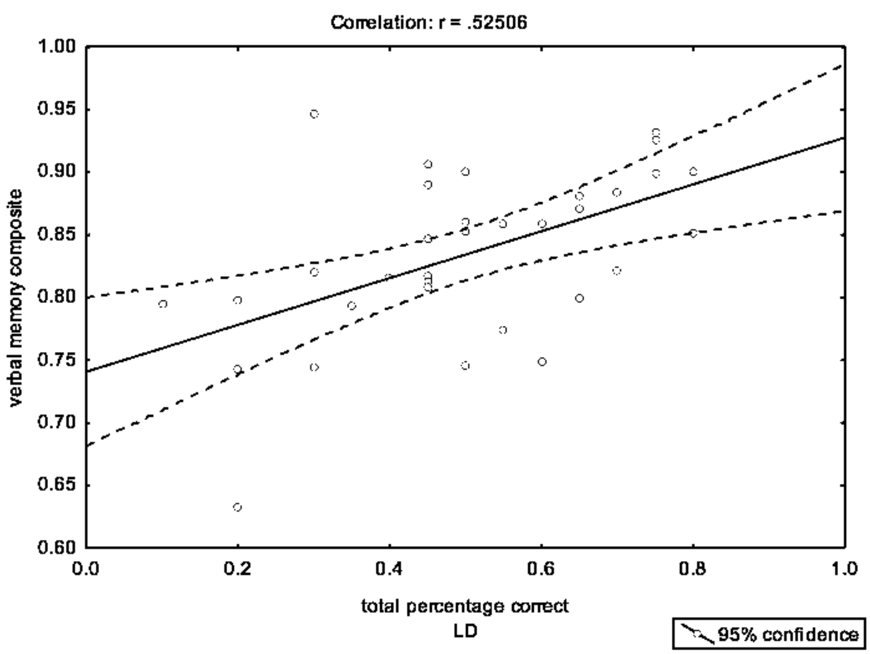

Figure 8. Verbal memory predicts post-test performance in students with LD

Relationships between measures of attention were then analyzed. A significant correlation was found between the CAARS-S:SV attention scale and the self-rating of attention to the lecture for all participants regardless of group (r=-.47, p=.01), suggesting that participants were reliable self-reporters of attention. The self-rating of attention correlates with post-test performance for the ND group (r=.64, p=.02), and the LD group (r=.55, p=.02), as shown in Figures 9 and 10. There was not a significant correlation between the CAARS-S:SV and learning performance. Due to late integration of both attention ratings there is missing data for these measures. For the self-rating of attention to the lecture, n=13/35 for the ND group and n=17/35 for the LD group. For the CAARS-S:SV, n=26/35 for the ND group and n=28/35 for the LD group.

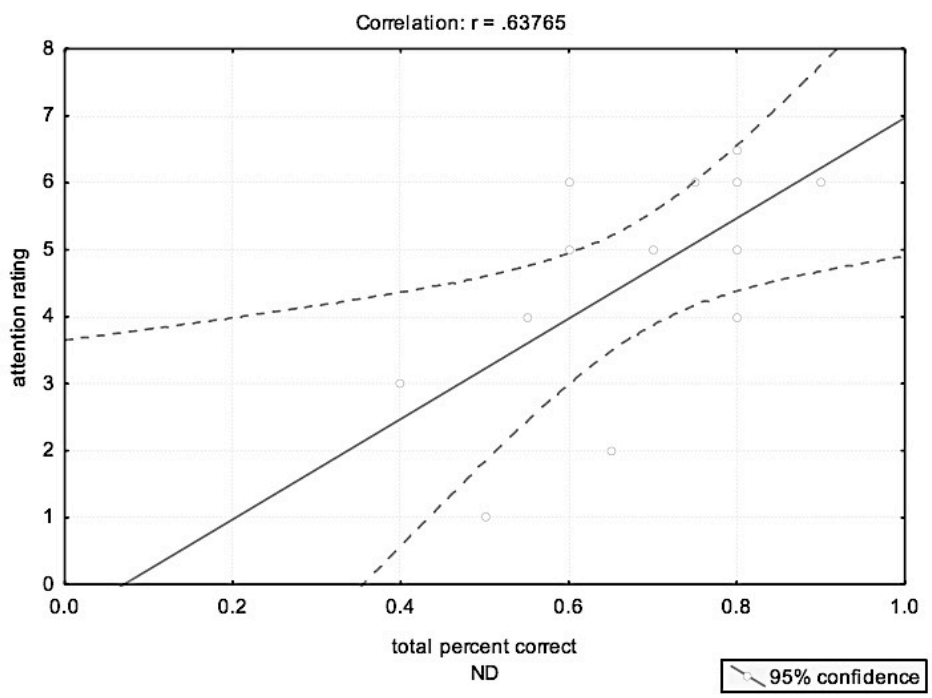

Figure 9. Attention predicts learning for ND students

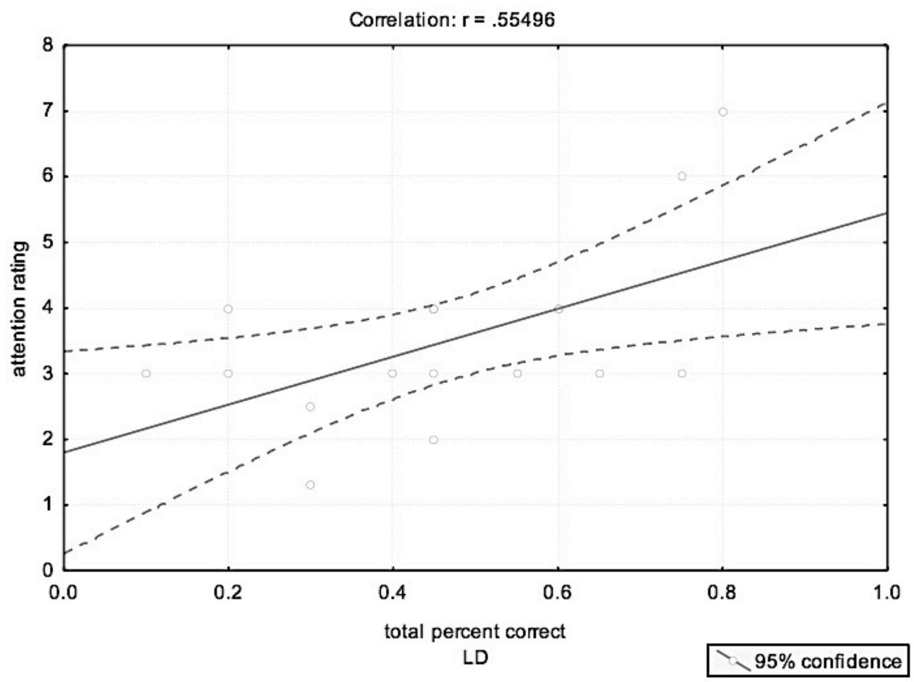

Figure 10. Attention predicts learning for LD students

CHAPTER IV: DISCUSSION

The primary hypothesis of this study was that auditory word learning is a weakness of students with LD. In particular, we hypothesized that college students with LD would learn verbally presented information in a lecture setting more poorly than ND students, given the same supports and environment. We found this to be so. Overall, ND students learned approximately 20% more than their peers with LD. In this section I will discuss the potential underlying deficit in terms of encoding, attention and vocabulary as well as implications of the results, limitations of the study and direction for future research.

Vocabulary

Significant correlations between vocabulary composite scores and post-test performance were found for both the ND and LD groups. This is not surprising. Vocabulary is built by learning new words, and many of those words are learned through the auditory modality. However, the relationship between the ability to learn new words and extant vocabulary knowledge may be reciprocal. The more easily one encodes words the better their vocabulary will be, and also the better one's vocabulary, the more easily they will encode new words. Frisch, Large, and Pisoni (2000) studied how wordlikeness affects the processing of nonwords, and the influence that prior language knowledge has on perceived wordlikeness. They posited that nonwords that were more word-like would be more distinct in memory, and therefore learned better, than nonwords that were less word-like if subjects relied on their prior knowledge about words in their language (e.g., phonotactic probability, word frequency, lexical neighborhood). They found that this was, indeed, the case – their subjects' prior knowledge of their language influenced how well they perceived, processed and recalled nonwords. Frisch et al. concluded that participants used prior knowledge of lexical patterns to improve recognition of nonwords that were similar to real words. This knowledge of lexical patterns comes from an individual's existing vocabulary, so it would be logical to conclude that one's vocabulary knowledge influences the ability to learn new words, including in the lecture format. As new words come up in lectures, the ability to fast-map new words, by way of matching phonotactic probability to old words, allows for more efficient, and more successful, learning.

Dollaghan, and Biber (1993) related extant vocabulary knowledge back to verbal memory performance as they examined the effects of vocabulary knowledge on outcomes of a nonword repetition task. They found that nonsense words were more accurately repeated when their stressed syllables corresponded to real words. Phonological memory (discussed further in detail in the next section) is limited in what it can hold and manipulate at a given time. It's possible that when nonwords have syllables that are similar to real words they can be chunked into larger segments (i.e., syllables rather than phonemes), thus expanding the absolute amount of information that can be held in short-term storage before being committed to memory. When an individual knows many words, they will have a heightened sophistication for phonotactic sequences, and therefore be able to hold nonwords better in memory.

Recall vs. Recognition

We predicted that expressive recall would be more sensitive to the ND-LD performance gap than recognition performance. This was the case at baseline, as ND participants performed only ~5% better than LD participants on multiple choice questions, but ~17% better on fill-in-the-blank questions. However, at post-test the LD group performed more poorly than the ND group on both question types, not exhibiting the relatively increased gap for expressive recall that we expected (ND performance was ~20% better on multiple choice questions and ~21% better on fill-in-the-blank questions). McGregor et al. (2013) and McGregor, Arbisi-Kelm and Eden (2014) both looked at recognition effects in ND and LD populations. McGregor et al. (2013) found a small difference between LD and ND groups in a word recognition task. However, the groups were only numerically, not statistically, different as both approached ceiling. In their 2014 study, McGregor et al. found significant effects in a similar word recognition task. Immediately after being trained on 24 novel word forms, ND and LD students were tested on encoding. On this task, the LD group recognized significantly fewer word forms than the ND group. We know that recall is inherently more difficult than recognition in general, but previous literature shows that recognition effects are elusive.

Memory and Attention

Recall that we defined "learning" as the moving of information into long-term memory, through the processes of encoding, consolidation and retrieval, as described by Walker and Stickgold (2006). Because previous literature points to deficits in the encoding stage for students with LD, we sought to explore two potential mechanisms that could underlie deficits during this stage. These were attention and verbal short-term memory. For this we refer to Baddeley's updated Model of Working Memory, as presented in Figure 2. This model includes the involvement of a central executive and three slave systems that consist of a phonological loop (for incoming auditory verbal information), a visuospatial sketchpad (for incoming visual, special and kinesthetic information) and an episodic buffer (for integrating information in short- and long-term memory from multiple domains). Our attention measures are indicative of the central executive function whereas our verbal short-term memory measures are more pertinent to the phonological loop function. The phonological loop is limited in capacity – a maximum of 7 +/- 2 items that must be quickly manipulated, processed and moved out of working memory in order to learn them before the next items roll in. If this does not happen, the information deteriorates and is lost. We found that attention – as measured by the post-lecture self-rating scale – was a significant predictor of post-test performance for both the ND and LD groups. In contrast, we found that short-term verbal memory was a significant predictor of post-test performance for the LD group only. Given these results, it is tempting to hypothesize that it is short-term verbal memory, in particular, the phonological loop, that is the defective encoding mechanism for students with LD. This would be consistent with reports implicating the phonological loop in the vocabulary problems of young children with LD. However, this causal relationship is thought to be developmentally limited (Jarrold, Baddeley, Hewes, Leeke, & Phillips, 2004). Moreover, the lack of relationship between short-term verbal memory and lecture performance in the ND group could simply reflect the limited range of scores they earned. This correlation may be different for ND and LD in part due to the fact that there was not enough variability in the ND group, and without variability we cannot achieve a significant correlation. It could also be possible that one only needs to achieve a particular threshold of verbal memory to successfully learn new information. As opposed to a continuum, where a slightly higher verbal memory score would result in a slightly higher post-test score (and visa versa), once a threshold is met we would no longer expect to see a correlation between success at post-test and verbal memory composite scores. From the results of our study we could suggest this threshold be an 85% on our verbal memory task, as the majority of subjects in both groups achieved over 50% on the post-test if they achieved at least 85% in verbal memory.

Other Contributors

Of course, learning, as it relates to memory, is not quite as simple as the few factors that are described above. Other possible contributors should be considered. Speed of processing is one such potential contributor to learning difficulties, especially in the classroom setting. If a lecturer is speaking at a speed deemed appropriate to the abilities of the average student, a student with a slower processing speed is bound to have difficulty. Working memory is very limited in terms of the quantity of information that can be maintained at a given time. For example, the phonological loop can only hold 7 +/-2 information units at a given time before they are either processed or lost. If a student with LD cannot process auditory information at the speed in which it is being said, their capacity of working memory will be exhausted, and subsequently, any information not processed and committed to long-term memory will be lost and replaced with more recent information. One can imagine that these students who are slower to processes auditory input will capture, and subsequently, learn, only "chunks" of what is being presented, potentially missing out on important concepts.

Metacognition and implementation of internal and external learning strategies are also potential factors when it comes to learning new information. Metacognition refers to the awareness of one's own cognitive processes. If a student has good metacognitive skills, they will be consciously aware of their strengths and weaknesses in the learning process as it unfolds. In a lecture, this would include the ability to recognize if one is paying attention to the lecturer, comprehending the concepts presented, and recognizing when difficulties arise. Metacognitive dexterity allows students to remediate any problems they are experiencing, and implement strategies to facilitate learning. Internal and external learning strategies can both be useful in the college classroom setting. Internal strategies include semantic association and elaboration (though this may be remarkably more difficult for students with LD as it relies on vocabulary and complexity of semantic networks, which has been shown to be compromised in this population), rehearsal, visual imagery, and many others. These are strategies that the student can implement without any external aid. External strategies include such things as organizers, visual aids (such as those provided by professors in the form of powerpoint notes), and technological accommodations (such as recording devices). Unfortunately, even if students have strong metacognitive skills, if they are unable to implement learning strategies when they recognize a deficit they may continue to find themselves having difficulties in the classroom.

One might also conjecture that it is not learning at all but expression of learning that matters in this study. The students with LD had to read the test questions and write the answers, and reading and writing are core challenges for these students. While granting that use of the written modality for testing may have limited their performance, it seems unlikely that it is the sole basis for their low performance. First, they had to read the multiple choice questions on the baseline test and they did not perform more poorly on these than their ND peers. Second, previous studies that test learning in a purely spoken modality also reveal a similarly sized ND-LD gap (Isaki & Plante, 1997; McGregor et al., 2013, 2014).

Implications

As we come closer to finding the underlying mechanisms involved in learning disabilities, we can begin to suggest more specific strategies for remediation. Given that prior research shows that impairment in memory for individuals with LD can generally be isolated to the encoding stage, strategies for improved encoding are implicated. Strategies that enhance attention (e.g., selection of shorter lecture schedules) and those that aid verbal short-term memory (e.g., reviewing recorded lectures, asking for repetitions) are implicated by the current evidence. Cognitive strengths should be sought and capitalized on. A student who has difficulty encoding auditorily but who may have a relative strength in print decoding could supplement classroom learning with additional readings. Additionally, this study has clinical implications that can be addressed at an early age. Assuming that vocabulary and encoding have a reciprocal relationship, vocabulary building should be an obvious target in language therapy. The earlier young children can build their vocabulary, the better their encoding skills are expected to be, resulting in better learning. Parents can be encouraged to use vocabulary-learning strategies – such as increased reading with their children, using appropriate language models with a variety of descriptive words, and extending or expanding what their children say.

Limitations

There were limitations to this study. Participants were not randomly assigned to a topic, as would be ideal. This was not implemented in order to rule out topic-familiarity, as subjects were assigned to the topic that they were least familiar with. Randomization would be ideal in future studies with larger groups of participants, where number can compensate for outlying participants who may be highly skilled in one area. An additional limitation is related to the fact that our lectures had minimal visual supports and were presented in an environment with few distractions. While these were important protocols for our study, in a real lecture there will likely be lots of visual support – particularly in the form of PowerPoint presentations with key words and multimedia, and there will also likely be more distractions than a lab room in a real lecture. Furthermore, it should be noted that participants in this study are not be representative of all individuals with learning disabilities. We expect this group to be quite high functioning, as they have been accepted into college programs. This is likely not the case for many other individuals with LD. Within the population of college students with LD, it's likely that other factors – such as time and motivation – influenced participation, and may also contribute to alternative college outcomes.

Further Directions

Further research into the mechanisms of LD in college students is warranted, as the current body of research for this particular population is scarce and lacks a high level of evidence. Future studies should be conducted in a more naturalistic college lecture environment to include typical supports as well as distractions that students may encounter. Randomization of participants in subsequent studies would boost the level of research, an important requirement of evidence-based practice. And finally, other factors, such as socioeconomic status, motivation, and use of classroom accommodations should be considered, addressed, and controlled for in subsequent experiments.

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APPENDIX A : LECTURE STUDY INTERVIEW

1. Have you had any college level courses in Philosophy? If so, which?

2. How would your 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”.

3. Have you had any college level courses in Physics? If so, which?

4. How would your 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”.

5. What are your note taking strategies during a lecture? (Do you take notes? If so, do you take written notes on blank paper? Do you take written notes on a printed powerpoint? Do you type your notes on a computer or iPad?)

6. What are your strategies for studying for a test? (Reading notes? Reading the book? Making flashcards? Taking practice tests?)

APPENDIX B : 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.
    a. Opposites
    b. Non-contradiction
    c. Reason
    d. Logic

14. _______________ is the belief that future events happen regardless of what someone does.
    a. Absolutism
    b. Nihilism
    c. Fatalism
    d. Passivism

15. While logos appeals to facts and logic, _______________ appeals to emotions.

16. A _______________ argument uses premises to show that a conclusion is true.
    a. deductive
    b. inductive
    c. productive
    d. 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."
    a. Comte
    b. Descartes
    c. Socrates
    d. 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.
    a. logic
    b. morality
    c. duty
    d. passion

APPENDIX C : 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?
    a. He is an atheist
    b. He will not break the law
    c. He feels the law is unfair
    d. Alcibiades convinces him to do so.

13. According to Socrates, the law is reason without:
    a. passion
    b. examination
    c. expression
    d. interpretation

14. Socratic philosophy includes the idea that "the ________________is not worth living".

15. In Plato's Republic, Socrates discusses:
    a. brains in vats
    b. teachers in a corrupt society
    c. prisoners in a cave
    d. 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?
    a. The state
    b. Knowledge
    c. The Socratic agenda
    d. Skepticism

18. What is the philosophical question/agenda that Socrates and Descartes both had in common?
    a. 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

APPENDIX D : 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:
    a. acceleration
    b. motion
    c. inertia
    d. velocity

8. Speed equals distance divided by _____________ .

9. A quantity that specifies a magnitude and a direction is called a:
    a. scalar
    b. vector
    c. constant
    d. 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.
    a. the same number of molecules
    b. more atoms
    c. fewer molecules
    d. the same number of atoms

12. The amount of energy a sound wave transmits is directly related to the wave's:
    a. shape
    b. frequency
    c. amplitude
    d. 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.

APPENDIX E : 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?
    a. Atoms should emit light of all colors.
    b. Hot objects should glow with ultraviolet light
    c. Atoms should emit electricity regardless of light
    d. 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?
    a. 10^-3
    b. 10^3
    c. 10^33
    d. 10^-33

8. If h were 0, the universe would be:
    a. discontinuous
    b. continuous
    c. relative
    d. 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:
    a. Photons
    b. Atoms
    c. Quantums
    d. 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