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Vocabulary Knowledge of Deaf and Hearing Postsecondary Students

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Abstract

Deaf children generally are found to have smaller English vocabularies than hearing peers, although studies involving children with cochlear implants have suggested that the gap may decrease or disappear with age. Less is known about the vocabularies of deaf and hard-of-hearing (DHH) postsecondary students or how their vocabulary knowledge relates to other aspects of academic achievement. This study used the *Peabody Picture Vocabulary Test* to examine the vocabulary knowledge of DHH and hearing postsecondary students as well as their awareness (predictions) of that knowledge. Relationships between vocabulary knowledge and print exposure, communication backgrounds, and reading and verbal abilities also were examined. Consistent with studies of children, hearing college students demonstrated significantly larger vocabularies than DHH students both with and without cochlear implants. DHH students were more likely to overestimate their vocabulary knowledge. Vocabulary scores were positively related to reading and verbal abilities but negatively related to sign language abilities. Among DHH students they also were positively related to measures of spoken language ability. Results are discussed in terms of related cognitive abilities, language fluency, and academic achievement of DHH students and implications for postsecondary education.

Keywords

Hearing loss; achievement; vocabulary; language; metacognition

This paper concerns the English vocabulary knowledge of postsecondary deaf and hard-of-hearing (DHH) students and their relative awareness of that knowledge as a function of several factors related to language and learning. According to the U.S. Department of Education, there are over 135,000 DHH students enrolled in postsecondary institutions in the United States, 54.5% of them in two-year programs and 43.4% of them in four-year programs, more than ever before (National Center for Education Statistics, 2008). Their persistence and graduation rates, however, are far below those of hearing students, due at least in part to their relatively poor English[1] language abilities. Qi and Mitchell (2012), for example, reported that the median reading level for 18-year-old DHH high school students

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[1]Although most of the relevant research in this area has involved “English,” the term is used generically here to refer to any written/spoken language.

was about the same as hearing 9- to 10-year-olds (4th grade), a situation that has changed little over the last 40 years. While they and others have provided detailed information concerning reading subskills of students in primary and secondary education (see Marschark & Spencer, 2011, chapters 7–10), much less is known about those subskills among DHH students in postsecondary education settings. The study described here focused on lexical knowledge in that population and its relation to reading and other academic skills.

The existing literature with regard to DHH students' lexical knowledge is bifurcated, with a number of studies demonstrating *quantitative* differences in the English lexicons of younger DHH and hearing students (see below), and others demonstrating *qualitative* differences in the lexical knowledge of postsecondary DHH students. McEvoy, Marschark, and Nelson (1999) and Marschark, Convertino, McEvoy, and Masteller (2004) used single word association tasks to examine the organization of English lexical knowledge in DHH and hearing college students, finding both between-group differences and greater variability among their DHH students than the hearing students. Words in DHH students' English lexicons were found to be less strongly interconnected (e.g., as indicated by primary associate strengths) and more idiosyncratic than those of hearing peers. Such findings have not yet been connected directly to learning outcomes or achievement, but they are associated with the well-documented reading challenges observed among DHH students at all levels (Spencer & Marschark, 2010; Chapter 6). The causes of such differences, as well as of the academic challenges to which they are related, are more complex.

Educating DHH Students

An in-depth history of deaf education is beyond the scope of the present paper (see Lang, 2011). It is important to note, however, that the history is a controversial one, particularly with regard to the language(s) of instruction, which might affect DHH students' vocabulary knowledge. In the United States, prior to passage of the Education for All Handicapped Children Act of 1975 (P.L. 94–142), 80% of DHH children were educated in special settings where instruction was most often offered through some form of signed communication. Today, more than 85% spend all or part of the school day in regular schools (Data Accountability Center, 2008). These classrooms may be bilingual with sign language support provided by a sign language interpreter or via co-enrollment programming in which there are two teachers, one of whom is a specialist in deaf education and provides instruction in sign language (see Antia, Stinson, & Gaustad, 2002; Marschark, Tang, & Knoors, 2014). Alternatively, the language of instruction for DHH students may be the written/spoken vernacular through a combination of assistive listening devices (e.g., FM systems, cochlear implants, hearing aids), real-time text, and attention to classroom acoustics.

Regardless of educational setting, the primary challenge facing DHH students in the classroom is communication accessibility. Over 95% of DHH children have hearing parents and, by virtue of their hearing losses and the relative inaccessibility of spoken language, most arrive at school with significant lags in language fluency relative to hearing peers (Knoors & Marschark, 2014, chapter 4). Deaf children of deaf parents, who have access to a natural sign language from birth, and those with cochlear implants, who have greater (but not full) access to spoken language, typically attain somewhat better academic outcomes

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than deaf children without those advantages, in part the result of having greater access to incidental learning through overhearing/overseeing the language of others. In the literacy domain, however, neither group generally achieves at the level of their hearing peers (see Knoors & Marschark, 2014, chapter 8, for a review). Reasons for this situation are still a matter of debate and empirical investigation, but relatively little attention has been devoted to the consequences of early language impoverishment and educational underachievement on long-term academic outcomes in terms of entry into and persistence in postsecondary education. The well-documented difficulties of school-aged DHH students in gaining literacy skills (Qi & Mitchell, 2012) are often seen as the major impediment to postsecondary academic success (Bochner & Walter, 2005), but the situation is not quite so straightforward.

Despite their students' chronic difficulties in reading, several recent studies involving DHH postsecondary students (e.g., Borgna, Convertino, Marschark, Morrison, & Rizzolo, 2011; Marschark et al., 2009; Stinson, Elliot, Kelly, & Liu, 2009) and school-aged DHH students (Marschark, Leigh, et al., 2006; Stinson et al., 2009) found that they learned just as much from text as they did from sign language or spoken language in the classroom. Those results suggest a limitation on the generality of findings indicating that early access to language via sign language can facilitate young DHH children's reading abilities (e.g., Padden & Ramsey, 2000; cf. Holzinger & Fellinger, 2014). They also suggest that the provision of sign language interpreting in postsecondary settings may not be sufficient to provide DHH students with full access to communication in the classroom.

One factor that might help to explain DHH students' difficulties in comprehending and learning from text relative to hearing peers is their *vocabulary knowledge* (Hanson, Shankweiler, & Fischer, 1983; Hermans, Knoors, Ormel, & Verhoeven, 2008). A number of investigators have noted that because of their hearing losses and related barriers to language and social interaction, DHH youth have fewer opportunities for vocabulary learning than their hearing age-mates, a situation that has long-term academic consequences (Easterbrooks & Estes, 2007; Trezek, Wang, & Paul, 2010). LaSasso and Davey (1987) and Paul and Gustafson (1991) demonstrated significant relations between vocabulary knowledge and reading achievement among DHH students in middle school and high school. But the importance of vocabulary knowledge in text comprehension goes beyond the individual word, also supporting higher-level aspects of processing including relational and inferential processing (Cain & Oakhill, 1999; Sénéchal, Ouellette, & Rodney, 2006), areas in which DHH students have been documented to have particular difficulty. Thus, even when they are provided with vocabulary support (e.g., contextually-relevant definitions), postsecondary DHH students have been found not to have sufficient facility with English vocabulary to benefit fully from age-appropriate reading materials (Borgna et al., 2011).

Intertwined with the findings described above are others from recent investigations demonstrating lesser accuracy (i.e., overestimation) among DHH than hearing postsecondary students in judging how much they understand and learn from reading and classroom instruction (e.g., Borgna et al., 2011; Marschark, Sapere, Convertino, & Seewagen, 2005). Results in this regard have been consistent across studies involving a variety of content presented via sign language, spoken language, real-time text, and printed materials. That phenomenon appears tied to underutilization of metacognitive resources for comprehension monitoring rather than indicating any generalized overestimate of their abilities or “self-aggrandizement” (see Kruger & Dunning, 1999; Stanovich & Cunningham, 1992, with regard to hearing students; and Marschark, Sarchet et al., 2012, with regard to DHH students). All of the relevant studies, however, have involved connected discourse. Beyond one study involving high school students (Krinsky, 1990), we are not aware of any investigations that have examined DHH students’ metacognitive or metacomprehension accuracy at the level of individual words. The present study therefore was designed to examine postsecondary DHH and hearing students’ (English) vocabulary knowledge as well as their accuracy in assessing that knowledge.

The *Peabody Picture Vocabulary Test* (PPVT) was the vocabulary measure of interest here, both because of its frequent use in previous studies involving DHH learners and because of its suitability for use across a wide age range. The PPVT is a well-documented receptive vocabulary test that has been normed for individuals across a wide age range and has proven extremely valid and reliable (coefficients > .90). Scoring provides age- and grade-based standard scores and percentiles as well as age and grade equivalents. With items at a broad range of difficulty level, the PPVT has been used with diverse populations including DHH children and young adults varying along dimensions such as early language experience, primary mode of communication (signed or spoken language), use of cochlear implants, and cognitive ability.

PPVT as a Measure of Vocabulary Knowledge Among DHH Students

Lesser vocabulary knowledge among DHH children than hearing children has long been acknowledged, at least for those with hearing parents (e.g., Griswold & Commings, 1974; Meadow-Orlans, 1987; see Spencer & Harris, 2006, for a review). Longitudinal studies of young deaf children of deaf parents also have revealed smaller sign language vocabularies in those children by age 3 (Anderson & Reilly, 2002; Woolfe, Herman, Roy, & Woll, 2010). Further, although it is frequently claimed that deaf children of deaf parents demonstrate greater literacy skills than deaf children of hearing parents, the research actually demonstrates only a correlation between the sign language skills of those children and their reading abilities; similar correlations are obtained between the spoken language skills of deaf children and their reading abilities (see Marschark & Lee, 2014). For the present purposes, we consider only DHH students’ vocabulary knowledge in the written/spoken vernacular (i.e., English). Recent research, however, has suggested that some forms of bilingual deaf education may provide those students with total, signed and spoken vocabularies quantitatively comparable to the vocabularies of monolingual or bilingual hearing peers (Rinaldi, Caselli, Onofrio, & Volterra, 2014). Qualitative aspects of such vocabulary knowledge have not yet been explored.

Geers (2006) noted that DHH children who rely on spoken language and “conventional amplification” (e.g., hearing aids, FM systems) typically develop language at about half of the rate of hearing children, averaging language delays of four to five years by the time they enter high school. Although evidence concerning the vocabulary knowledge of DHH students at the postsecondary level is scarce (Auer, Bernstein, & Tucker, 2000), the PPVT has been used in a variety of studies to evaluate that knowledge in younger DHH students (e.g., Eisenberg, Kirk, Martinez, Ying, & Miyamoto, 2004; Moeller, 2000; Moeller, Osberger, McConkey, & Eccarius, 1981). In general, those studies have indicated, somewhat surprisingly, that English vocabulary knowledge is independent of whether DHH students rely primarily on sign language or spoken language. This finding presumably reflects the emphasis on reading English in school regardless of a student's primary mode of interpersonal communication.

Similar results have been obtained from studies involving DHH children with cochlear implants. Although benefits decrease with age (see Spencer, Marschark, & Spencer, 2011), cochlear implants improve hearing and speech for most deaf children with profound hearing losses and, partly as a result, they often demonstrate higher levels of reading achievement, at least in lower grades (e.g., Archbold et al., 2008; Geers, Tobey, Moog, & Brenner, 2008). Because in the United States implants were approved for use with children as young as 2 years only in 1990 and those as young as 18 months in 2002, studies addressing achievement among early-implanted high school and postsecondary students are not yet available. In a study involving a nationally-representative sample of more than 450 DHH students aged 13–16 years, however, Marschark, Nagle, Shaver, and Newman (in press) found that achievement in reading, mathematics, social science, and science was unrelated to whether or not students used cochlear implants when other variables were controlled. Convertino, Marschark, Sapere, Sarchet, and Zupan (2009) similarly found that implant use was not a significant predictor of classroom learning in a sample of over 750 DHH postsecondary students when other factors were controlled.

Fagan, Pisoni, Horn, and Dillon (2007) found PPVT scores among 6-to-14-year-old deaf children with cochlear implants to be well below those of hearing age-mates. However, when Fagan and Pisoni (2010) reanalyzed their earlier data utilizing *hearing age*, the length of time the children had used their cochlear implants, rather than chronological age, they found the children's PPVT scores to fall within the average range. Stelmachowicz, Pittman, Hoover, and Lewis (2004) found lower PPVT scores in deaf children with cochlear implants than their hearing peers, but a steeper slope in the regression line relating PPVT scores to age led them to hypothesize that lags in vocabulary growth among children with implants might disappear as they get older. A similar hypothesis was put forward by Hayes, Geers, Treiman, and Moog (2009), given the rapid growth in PPVT scores they observed in children following cochlear implantation. Conner, Craig, Raudenbush, Heavner, and Zwolan (2006), however, found that earlier implantation was associated with greater rates of PPVT vocabulary growth only up to four years after implantation, after which vocabulary growth rates were the same regardless of the age of implantation.

Although the Stelmachowicz et al. (2004) and Hayes et al. (2009) proposal does not appear to match the experiences of most teachers of DHH children or the available data (see Luckner & Cooke, 2010), there is a methodological difficulty involved in the above studies. Standard administration of the PPVT involves the examiner saying a stimulus word and the examinee pointing to the appropriate picture, clearly creating a bias against DHH individuals, even if they use cochlear implants. Some of the studies above presented the PPVT stimulus words in both speech and sign ("simultaneous communication"), but most children who use cochlear implants depend on spoken language, and it is unclear how much they would benefit from the additional signs (but see Giezen, Baker, & Escudero, 2014). Most of the research described above simply did not address the language modality issue, assuming that children who relied on spoken language had sufficient skills for purposes of the PPVT.

In order to avoid a bias against children who used sign language, Forde (1977) and Bunch and Forde (1987) created print forms of the PPVT. Although the results were not compared to the hearing norms, Forde found consistent increases in vocabulary growth in his DHH students until the sixth grade, followed by a slight decrease among his oldest group of 13- to 14-year-olds. Bunch and Forde obtained similar results with a greater decline in the oldest group (13–14 years). Radić, Bradarić-Jončić, and Farago (2008) also created a print version of the PPVT for use with DHH students, with the stimulus words printed in Croatian. Thirty five percent of the 15- to 21-year-olds had cochlear implants, although the average age of implantation was 13 years. Overall, mean scores were at the level of 10-year-old hearing children according to American norms, and there was no difference between students with and without cochlear implants.

In summary, the above studies are consistent in documenting DHH children's smaller vocabularies in the written/spoken vernacular than hearing age-mates across a wide age range (and using various editions of the PPVT). English vocabulary differences are not found between those students who rely on spoken language and those who rely on sign language or between those who use cochlear implants and those who do not. Still to be determined is whether the vocabulary gap between DHH children with cochlear implants and their hearing peers really does disappear with age, as suggested by Stelmachowicz et al. (2004) and Hayes et al. (2009), and whether language skills in spoken versus sign language emerge as predictors of vocabulary at some later point. These issues were addressed in the present study together with questions concerning postsecondary DHH and hearing students' awareness of their vocabulary knowledge.

The Present Study

There were two primary motivations for the present study, both alluded to above. First is a general interest in understanding qualitative and quantitative aspects of postsecondary DHH students' lexical knowledge as it relates to their reading experience and to learning more generally. Marschark and Knoors (2012) described the importance of understanding differences between the ways that DHH and hearing students organize and use their lexical and world knowledge, a matter of particular importance as increasing numbers of DHH students find their way into mainstream postsecondary classrooms. Although such differences have not previously been examined in the context of academic achievement, McEvoy et al. (1999) and Marschark et al. (2004) showed that hearing college students have stronger associations between words and their primary associates and that DHH students are more heterogeneous in their associations among lexical concepts, both factors assumed to affect reading. Those findings led us to expect that in the present study hearing students would demonstrate greater vocabulary knowledge than DHH students, even though all of

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them were college students and thus a more selective sample than those in studies involving younger students.

Consistent findings indicating that DHH college students overestimate their world and academic knowledge to a greater extent than hearing peers (e.g., Borgna et al., 2011; Marschark et al., 2005) led us to expect a similar finding with regard to vocabulary knowledge. Toward this end, prior to administration of the PPVT, each student in the present study was given a list of all of the stimulus words and was asked to identify those for which they knew the meanings.

The issue of DHH and hearing college students' accuracy in predicting their vocabulary knowledge, and the second motivation for this investigation, relate to a study by Auer et al. (2000). That study is apparently the only other one that has utilized the PPVT with postsecondary students. Auer et al. were interested in DHH and hearing individuals' recognition of printed words as a function of word frequency and familiarity, expecting that because of their lesser exposure to English, DHH individuals would give lower familiarity ratings. A print version of the PPVT was administered to provide an independent index of vocabulary knowledge. DHH participants in the Auer et al. study were all university undergraduates who utilized spoken or signed English but self-reported English as their first language. The hearing participants were either graduate students, university employees, or employees of the investigators' clinical/research center. Consistent with their expectations, the investigators found that the DHH students rated words as less familiar than the hearing participants. Given the lack of language-related differences in the studies described earlier, however, it is unclear whether those results were the result of the English skills of the DHH and hearing participants or differences in their educational levels. The present study therefore involved samples of hearing and DHH students attending the same university, including examination of their academic credentials, communication histories, and print exposure.

Method

Participants

A total of 93 DHH students and 97 hearing university students at Rochester Institute of Technology (RIT) volunteered to participate in the study for $10 each. RIT includes the National Technical Institute for the Deaf (NTID) as one of its nine colleges, but DHH and hearing students were drawn from programs across the university. Participation involved completing the PPVT and the corresponding pretest vocabulary checklist, a Title Recognition Test tapping students' reading backgrounds (i.e., print exposure; Stanovich & Cunningham, 1992), and a communication questionnaire. Students also gave the investigators permission to access university entrance scores from institutional records. Hearing thresholds (pure tone averages in the better ear or PTA) were available for 86 of the DHH participants. The mean PTA was 87.2 dB (*SD* = 30, range = 37–120). Twenty-nine deaf students indicated that they used cochlear implants (mean age of implantation = 8.6 years).

Materials and Procedure

The following tasks were administered by one of two researchers, both of whom were also highly skilled sign language interpreters with more than a decade of experience in the RIT setting. As students appeared at the laboratory, they were given the pencil-and-paper tasks and the PPVT in the order below. Instructions and explanations were provided to students in sign language, spoken language, or both, depending on student hearing status and preference. None of the tasks was timed.

PPVT Pretest—The first task involved a list of the 120 stimulus words to be used in administration of the PPVT (see below). Students were told: “If you know the meaning of the word, please put a check in the box next to it.”

Title Recognition Test—The Title Recognition Test (TRT) was developed by Marschark, Sarchet et al. (2012) in their examination of relations among print exposure, academic achievement, and reading habits of DHH college students. That TRT is patterned on TRTs used by Stanovich and colleagues (e.g., Stanovich & Cunningham, 1992) and includes 80 real book titles and 80 invented foils. Within the list of real titles, 20 correspond to reading materials appropriate for kindergarten through third grade, 20 for fourth to sixth grade, 20 for seventh to eighth grade, and 20 for ninth to 12th grade. The foils were created so as to similarly parallel the same grade levels, 20 in each. In the present study, only the 120 titles appropriate for fourth to 12th grade were used, parallel to the PPVT stimulus range. Students saw a randomly-ordered list of the titles and simply checked a box next to each of the titles that they recognized, whether or not they had read them.

PPVT—Each stimulus set in the PPVT-4 (Dunn & Dunn, 2007) contains 12 words and a corresponding stimulus card containing four pictures. The task normally is administered (to hearing individuals) by the examiner saying an English word and having the examinee point to the corresponding target picture. Because many of the PPVT pictures are not simple referents of words/signs and because the study involved a sample of university students, the task was modified to allow presentation of a printed word followed by an appropriate pointing response. This study utilized PPVT-4 item Sets 9 (age 10) through 18 (adult), for a total of 120 items being presented to each student. Each of the 120 stimulus cards was scanned (black-and-white) and placed on a PowerPoint slide, completely filling the slide, with an item number (1–120) and the appropriate stimulus word printed in the center in 24-point Calibri font. Students worked through the 120 items in the prescribed order either on a laptop computer or a Barnes & Noble Nook™. With the former, they indicated their response on an answer sheet; with the latter, they pressed the appropriate response picture on the screen, which was recorded by the Nook.

Communication Questionnaire—The language and communication skills of DHH students entering RIT are evaluated for the purposes of service provision through the Language and Communication Background Questionnaire (LCBQ). RIT utilizes this pencil-and-paper self-report measure instead of face-to-face communication interviews because it is faster than interview assessments, can be administered online, and correlates around .80 with interview assessments (McKee, Stinson, & Blake, 1984). The version of the LCBQ used here asked DHH students the age at which they learned to sign and had them rate their skills in understanding and producing ASL, signed English (without voice), simultaneous communication (speech and sign together), and their skill in understanding spoken language (without sign), all rated along five-point scales. In addition, they were asked to indicate their preferences for using ASL versus signed English and sign language versus spoken language as well as their use of hearing aids and cochlear implants. The communication questionnaire given to the hearing students asked, among other things, “How much American Sign Language do you know?” Response choices were “I don’t know any,” “I know a little,” “I am able to have a conversation,” and “I’m fluent,” which were scored as 0 to 3, respectively.

Scoring

For each student, several PPVT measures were calculated. Using the standard scoring method for the PPVT-4 (Dunn & Dunn, 2007), Set 9 was considered the *basal set* and the *ceiling item* was the last item in the *ceiling set*, that is, the last item in the set in which the individual had eight or more errors (normally, testing would end when eight errors were made in a set). This allows calculation of a standard score and, using the student’s birthdate, an age-adjusted percentile score. In addition, for each student, the number of PPVT *overestimates* (items that students indicated on the pretest that they knew but which they got wrong), the number correct in each set, and the total number correct were obtained for the analyses described below.

TRT scores are obtained by subtracting the number of foils incorrectly identified from the number of real titles checked by each student. This provides a corrected estimate of students’ print exposure (Stanovich & Cunningham, 1992). In addition to a total TRT, separate TRTs were calculated for each of the three (age) levels of book titles.

College entrance scores were available for 176 of the students (86 DHH, 90 hearing). RIT permits prospective students to take either the American College Test (ACT) or the SAT. Most DHH students take the ACT, most hearing students take the SAT, and some students take both. In order to have a single verbal score for the purposes of this study, we utilized the ACT/SAT conversion recommended by the College Board (Dorans, 1999, p. 13) which converts SAT Verbal scores to a composite verbal score corresponding to ACT Reading + English scores.

Results

In the following, unless indicated otherwise, all and only those effects reported were significant at the .05 level.

PPVT

Because the addition of stimulus words to the PPVT cards was non-standard, the reliability of the scores was evaluated using Cronbach alpha analyses for all 120 items. Scores proved highly reliable for both DHH (alpha = .92) and hearing (alpha = .81) students. Consistent with previous studies involving children, the hearing college students obtained higher PPVT scores than the DHH college students using both PPVT standard scores, $F(1, 189) = 197.78$, MSE = 141.95, and percentiles, $F(1, 189) = 260.84$, MSE = 379.48, as dependent variables in a one-way ANOVAs.

In order to examine possible differences between DHH and hearing students in the vocabulary intended for individuals of different ages, the number of items correct in each of the 10 vocabulary sets administered, Sets 9 (age 10) through 18 (adult), was examined using a 2 (hearing status) by 10 (vocabulary sets) ANOVA in which the second factor was within subjects. In addition to a main effect of hearing status, $F(1, 188) = 192.38$, MSE = 13.70, reflecting the better performance of the hearing students, and a main effect of set, $F(1, 18) = 481.70$, MSE = 1.87, reflecting the greater difficulty (lower scores) of sets intended for older individuals, there was also a significant interaction of hearing status and set, $F(1, 189) = 38.82$. As can be seen in Figure 1, hearing students scored near the maximum of 12 correct in Sets 9 through 14 (age 16) before their scores showed a large drop, whereas a comparable drop in the DHH students' scores occurred with Set 11 (age 13). The largest drop for the hearing students (from Set 16 to Set 17) occurred two sets later than it did for DHH students (from Set 14 to Set 15), although both were in the range of stimuli for ages 19 to adult. Independent sample t-tests indicated that all of the differences between the two groups were significant, all $ts(188)>4.58$. The DHH and hearing students' mean PPVT standard scores of 82.06 and 106.34, respectively, were very close to the 89.9 and 109.5, respectively, reported for DHH students by Auer et al. (2000).

Students' beliefs about their vocabulary knowledge, that is, words they had indicated they knew prior to completing the PPVT, were analyzed using a similar 2 (hearing status) by 10 (vocabulary sets) ANOVA with overestimates as the dependent variable. Within each set, overestimates were the number of items that students indicated they knew but on which they subsequently were incorrect. The analysis yielded a significant main effect of hearing status, $F(1, 188) = 271.84$, MSE = 9.35, as DHH students overestimated their vocabulary knowledge to a greater extent than hearing students, a significant main effect of set, $F(1, 188) = 1.69$, MSE = 1.53, as overestimates generally increased with set difficulty, and a significant hearing status by set interaction, $F(1, 188) = 14.67$. As can be seen in Figure 2, overestimates largely tracked the total correct in each set (and hence the number of errors). Independent sample a priori *t*-tests indicated that DHH students overestimated their performance significantly more than hearing students in Sets 9 through 16, all $ts(188) > 2.98$, but the two groups did not differ in the most difficult Sets 17 and 18, $ts(188) < 1$. A similar set of within-subjects analyses examined students' estimates relative to the actual number correct in each set (essentially, the difference in the data points in Figures 1 and 2). DHH students significantly overestimated their scores in each set, all $ts(92) > 5.45$. Hearing students did so only on Set 17, $t(96) = 2.54$, while they underestimated their performance on Set 14, $t(96) = -3.81$ and Set 16, $t(96) = -2.22$.

Print Exposure

Consistent with the findings of Marschark, Sarchet, et al. (2012), the hearing students had significantly higher TRT scores than the DHH students, $F(1, 189) = 11.27$, MSE = 156.50, indicating greater print exposure. Examination of TRT scores at the three different reading levels utilized a 2 (hearing status) by 3 (reading level: grades 4–6, 7–8, 9–12) ANOVA in which the second factor was within subjects. Hearing students' TRT scores were considerably higher than those of the DHH students at all age levels, yielding a main effect of hearing status, $F(1, 189) = 11.27$, MSE= 55.50. There also was a main effect of book age level, $F(2, 188) = 45.84$, MSE= 4.62, but the interaction was not significant $F<1.0$. For both groups, TRTs were highest for titles at the level of grades 7 to 8 and lowest for titles at the level of grades 9 to 12. At these two levels, the DHH students, on average, actually identified (erroneously) more foils than actual titles (see Table 1).

Academic and Communication Data

Although all of the DHH students participating in this study had entrance scores sufficient for admission to RIT, their composite verbal scores were significantly lower than those of the hearing students, $F(1, 175) = 245.11$, MSE = 80.03. The relations among students' verbal composite scores, their PPVT scores (standard, percentile, overestimates), and their TRT scores first were examined using Pearson correlations. Table 2 provides the correlation coefficients for DHH and hearing students (in the top half and bottom half, respectively), where it can be seen that the two groups demonstrated essentially the same pattern of relations among those variables. Beyond composite verbal scores, ACT Reading Comprehension scores were available for 81 of the DHH students and 44 of the hearing students (see Table 2). Among the DHH students, those scores were significantly related to both PPVT standard scores, $r\ (80) = .59$, and PPVT percentiles, $r\ (80) = .60$. In the smaller group of hearing students, ACT those scores were significantly related to both PPVT standard scores, $r\ (43) = .50$, and PPVT percentiles, $r\ (43) = .54$.

DHH students who reported that they had a cochlear implant (29) were not significantly different in their TRT, PPVT, or verbal scores from the students who did not (61), all $ts(88) < .96$ (3 of the 93 DHH students did not answer the relevant question). Relations among the DHH students' communication skills and their TRT, PPVT, and verbal scores were evaluated using Pearson correlations. As can be seen in Table 3, DHH students' self-rated spoken language comprehension skills and their preferences for spoken language over sign language were positively related to both their PPVT scores and their verbal composite scores. DHH students' ASL comprehension and production skills were negatively related to their PPVT scores, and ASL production skills were negatively related to their composite verbal scores. Better ASL comprehension skills were associated with more PPVT errors.

While the above pattern of results might be interpreted to indicate that DHH students who use spoken language have an academic advantage, at least with regard to their English vocabularies, one puzzling finding suggests caution in that regard. Although just over 37% of the hearing students indicated that they knew no ASL and less than 15% indicated that they knew enough to carry on a conversation, self-ratings of their ASL skills were significantly related to both their PPVT percentile scores, $r\ (89) = -.25$, and their verbal scores, $r\ (96) = -.25$, just as they were for the DHH students. In an effort to determine whether the negative relations between ASL skills and vocabulary scores among older hearing students were specific to sign language or a more general effect of second language skill, follow-up queries were sent to all 97 of the hearing students. They were asked to rate their second (spoken) language skills using the same scale as they had rated their ASL skills:

"I don't know any," "I know a little," "I am able to have a conversation," and "I'm fluent," which again were scored as 0 to 3 respectively. Sixty (62%) of the students responded. Correlations among their second spoken language skill, ASL skills, PPVT scores, TRT, and composite verbal scores indicated no significant relations, all *r*s (59) < .16.

A final set of analyses sought to predict composite verbal scores separately for the DHH and hearing students. The stepwise multiple regression analysis for hearing students, including PPVT scores (standard, percentile, overestimates) and TRT scores as the predictor variables, yielded only the PPVT percentile score as a significant predictor, accounting for 46% of the variance (β = .68). The analysis of the DHH students' data also included self-ratings of their communication skills and their hearing thresholds. Their PPVT percentile scores accounted for 39% of the variance (β = .62), with an additional 4% accounted for by their rated comprehension of signed English (total model β = 1.46).

Discussion

The present study examined DHH and hearing postsecondary students' vocabulary knowledge and their awareness of that knowledge as a function of several factors related to language and learning. Carver (1994) suggested that comprehension will be significantly impeded if a reader does not understand at least 90% of the words in a text. Consistent with previous studies primarily involving younger students, the large sample of DHH college students in the present study scored lower on the PPVT than did their hearing peers, correctly identifying words at that 90% criterion only in sets intended for 9- to 10-year-olds. Earlier studies by Forde (1997), Bunch and Forde (1987), and Moeller et al. (1981), however, had observed plateaus in PPVT scores among DHH students during their teenage years, even though Moeller et al. saw significant vocabulary growth in high school students. Whatever the locus of the observed plateau, the present results indicated that DHH students' vocabulary knowledge continues to lag behind hearing peers into the postsecondary years. For both DHH and hearing students, PPVT scores were significantly related to reading ability and general verbal ability as indexed by college entrance scores. Indeed, the PPVT was the most potent predictor of students' composite verbal scores.

Stelmachowicz et al. (2004) and Hayes et al. (2009) had found rapid growth in vocabulary after children had received cochlear implants, leading both sets of investigators to suggest that DHH children are likely to catch up with their hearing peers if they used implants. As in previous studies involving children (Conner et al., 2006; Fagan et al., 2007), cochlear implants and hearing thresholds were not related to vocabulary scores among the DHH college students in the present study, although the late mean age at implantation in the present sample, like that of Radić et al. (2008), makes any strong conclusion in that regard tenuous. Pediatric cochlear implantation clearly has a significant positive impact on the hearing, speech, and academic abilities of DHH children even if they still generally lag behind hearing peers in all of these domains (see Spencer et al., 2011). Whether or not those gaps will close for individuals receiving their devices at "the new early" age of 12 months and younger remains to be seen.

Beyond having smaller vocabularies than hearing peers, the postsecondary DHH students in this study were less accurate in predicting which words they did know. As a group, the DHH college students significantly overestimated their vocabulary knowledge in all 10 of the vocabulary sets and did so to a significantly greater extent than the hearing students. Those findings extend earlier findings in which postsecondary DHH students were found to overestimate their language comprehension and learning in the classroom to a greater extent than hearing students regardless of whether information was presented through spoken language, sign language, or text (e.g., Marschark, Sapere, et al., 2005). Borgna et al. (2011) suggested that the locus of such metacognitive inaccuracy might lie in the *unskilled and unaware effect* (Kruger & Dunning, 1999), as lesser content knowledge and language fluencies may leave DHH students with the “double burden” of poor comprehension and less awareness of it. In the case of vocabulary, weaker associations among lexical concepts also reflect more diffuse associative structures and lesser automaticity in meaning activation (McEvoy et al., 1999).

Looking Ahead: Implications for Research and Practice

Further research will be needed to elaborate how lesser vocabulary knowledge and differing organization of lexical knowledge might be related to the observed metacognitive overestimates and the relative ineffectiveness of vocabulary-related manipulations intended to improve DHH students’ learning (Borgna et al., 2011; Krinsky, 1990). The Borgna et al. finding that providing vocabulary and context-relevant definitions were insufficient to improve DHH students’ learning suggests that interventions that lead to stronger and/or more cohesive relations are necessary in order for them to provide support for ongoing comprehension (Davis, 1944; Rawson & Kintsch, 2002). Together with the present findings, these findings also suggest that many DHH college students do not have sufficient English word knowledge to support ongoing text comprehension, a situation only compounded by the lesser likelihood of ongoing comprehension monitoring.

Two additional results from the present study are in need of further investigation. First, the relation of PPVT and verbal scores observed here and by Auer et al. (2002) appears to emphasize the importance of vocabulary in postsecondary DHH students’ overall functioning in English. Alternatively, that relation simply may be a reflection of the emphasis on vocabulary in college entrance tests like the ACT and SAT. Findings indicating that PPVT scores were significantly related to ACT Reading Comprehension scores but not TRT scores suggests that students’ print exposure does not directly affect their vocabulary knowledge as much as might be expected. That finding would argue for recognition of the importance of incidental learning of vocabulary and knowledge of the world, and thus perhaps the need for explicit teaching of vocabulary to DHH learners throughout childhood and the school years, with continuing emphasis during postsecondary education.

Finally, the inverse relation observed here between DHH students’ ASL skills and their PPVT scores, together with positive relations of their spoken language skills and English signing receptive skill with PPVT scores suggests a “natural” link between spoken English and English vocabulary. A similar inverse relation between the ASL skills of hearing students and their PPVT scores, however, indicated that the explanation was not so simple.

Children who are bilingual in two spoken languages have been found to have smaller vocabulary skills within each language than monolinguals (e.g., Ben-Zeev, 1977), although their vocabularies in the two languages combined may be comparable. Rinaldi et al. (2014) recently obtained similar findings in research involving bilingual DHH students who demonstrated total, signed and spoken vocabularies comparable to hearing monolingual peers. Findings from the PPVT studies described above, however, suggest that neither sign language nor spoken language leads to an advantage in DHH students' vocabulary development discernible by the time they reach postsecondary education. Further, longitudinal studies of DHH children acquiring ASL and BSL from their DHH parents have indicated that even children acquiring sign language from birth often exhibit vocabulary delays (Anderson & Reilly, 2002; Woolfe et al., 2010).

Taken together, results from the existing literature and those obtained here all point to relatively poor vocabulary skills among postsecondary DHH students, regardless of their primary mode of communication, whether or not they use cochlear implants, or the mode in which vocabulary is assessed. It seems likely that this situation derives in large part from the lesser availability of incidental learning via language of in school and out (Dunn & Dunn, 2007, p. 4). Less clear at this point are specific consequences of this quantitative difference as well as qualitative differences in the organization of lexical knowledge that have been documented among postsecondary DHH students relative to hearing peers. Both factors likely are related to the reading and classroom learning challenges typically observed among DHH learners, also reflecting somewhat less and somewhat different knowledge of the world. Similar, if more limited findings with regard to children who are blind (e.g., McConachie, 1990; McConachie & Moore, 1994) suggest that limited access to the world through sight or hearing – and experience with the correlation between them – can have some similar consequences. Theoretical, physiological, and practical implications of such situations remain to be elaborated.

Over half of the two-year and four-year postsecondary institutions in the United States report enrolling one or more students who self-identify as deaf or hard of hearing (NCES, 2008). Perhaps the most important implication to be drawn from the present study for those institutions is that deaf students are not simply hearing students who cannot hear. DHH students are far more heterogeneous than their hearing peers, and just because they do well enough in high school and on entrance examinations to get into postsecondary programs does not mean that their qualifications necessarily are quantitatively or qualitatively the same as hearing classmates. A variety of studies has demonstrated cognitive differences between DHH and hearing students, during the school years and in postsecondary settings, that are likely to affect classroom learning (Marschark & Knoors, 2012). If postsecondary institutions are going to admit DHH students with diverse special educational needs, they must recognize that modifications of materials and instructional methods may be necessary in order to take advantage of those students' strengths as well as to accommodate their needs.

The large individual differences found among DHH students, as well as others with special education needs, points to three limitations on the present study. First, students' language skills were assessed indirectly, through-self ratings. Although the instrument used to obtain those ratings has been found to be valid and reliable in the past, this population is changing rapidly, and more direct assessments of signed and spoken language skills would provide a more precise understanding of relations among those skills, vocabulary knowledge, and learning. Not unrelated is the rapidly increasing prevalence of cochlear implant use among deaf postsecondary students. As noted earlier, the average age of implantation in the present sample was relatively late, and further study involving students who received their implants earlier would be useful for understanding future student cohorts. Future studies also would benefit from considering students' vocabulary knowledge in the context of their broader knowledge of the world. Vocabulary knowledge is neither a unitary construct nor divorced from other knowledge of the world. Given the acknowledged heterogeneity of the DHH student population and demonstrations of differences in organization of their semantic memories relative to hearing peers, examination of the breadth and depth of their conceptual knowledge would be of both theoretical and practical value.

More than a century of efforts to ameliorate the academic underachievement of DHH students has clearly demonstrated that "one size does not fit all." As their numbers in postsecondary education continue to increase, it is essential that programs recognize that childhood hearing losses have lifelong implications for learning. Differences between DHH and hearing students do not necessarily reflect insurmountable challenges, but they do need to be acknowledged by students, instructors, and institutions if all are to succeed in the educational endeavor.

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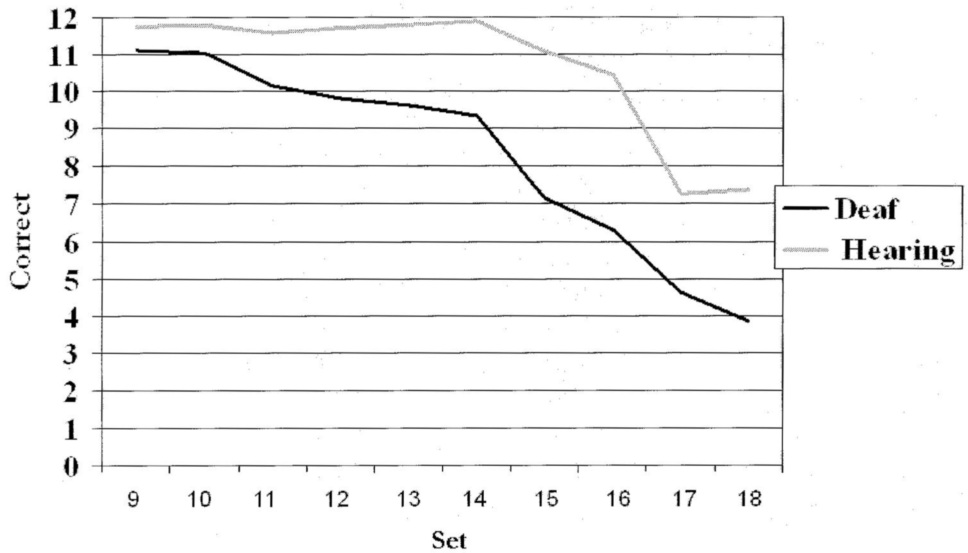

Figure 1.
Deaf and hearing students' PPVT mean scores per set (maximum=12)

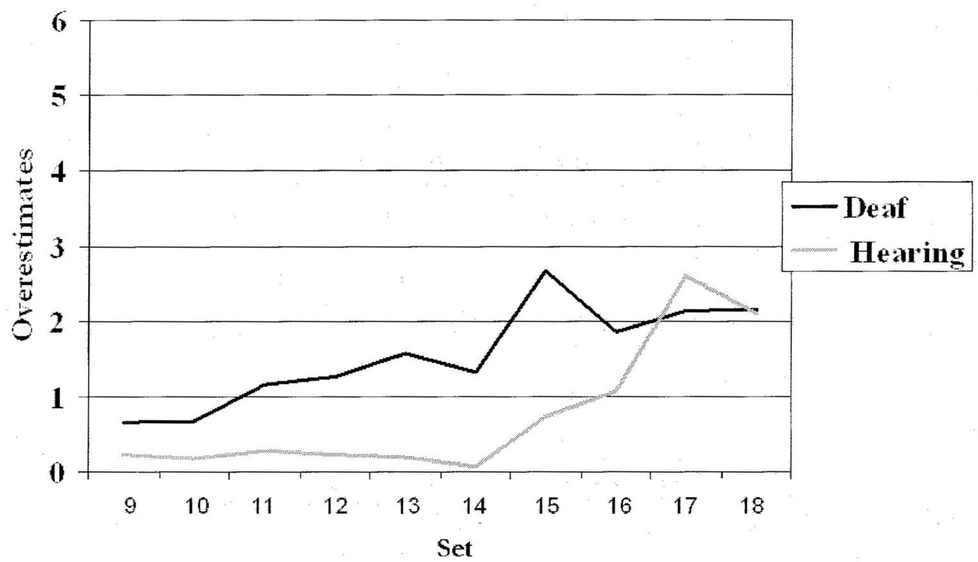

Figure 2.
Deaf and hearing students' overestimates of PPVT word knowledge (maximum=12)

Table 1

Means (standard deviations) for Title Recognition Test (TRT), Peabody Picture Vocabulary Test (PPVT), composite verbal scores, and ACT Reading Comprehension scores

	Deaf	Hearing
TRT Total	.08 (6.14)	6.36 (17.03)
TRT Grades 4–6	−.22 (2.32	2.14 (4.98)
TRT Grades 7–8	1.17 (2.49)	3.19 (6.52)
TRT Grades 9–12	−.88 (2.88)	1.03 (.36)
PPVT Standard Score	82.06 (14.47)	106.34 (8.79)
PPVT Percentile	19.43 (19.60)	65.09 (19.37)
PPVT Overestimates	15.46 (12.92)	7.67 (4.80)
Composite Verbal Score	33.55 (8.58)	54.67 (9.28)
ACT Reading Comprehension	18.35 (4.70) [n=81]	27.52 (5.20) [n=44]

Table 2

Correlation coefficients for Title Recognition Test (TRT), Peabody Picture Vocabulary Test (PPVT), and composite verbal scores for deaf students (upper half) and hearing (lower half) students.

		DEAF				
		PPVT Standard Score	**PPVT Percentile**	**PPVT Overestimates**	**Composite Verbal Score**	**TRT**
	PPVT Standard Score	-	.89**	−.49**	.61**	−.07
	PPVT Percentile	.98**	-	−.40**	.62**	−.04
	PPVT Overestimates	−.56**	−.57**	-	−.22*	.03
	Composite Verbal	.65**	.68**	−.27*	-	.13
HEARING	TRT	.06	.03	−.14	.07	-

Note.

* $p < .05$

** $p < .01$

Table 3

Correlation coefficients for TRT, PPVT, composite verbal scores, and deaf students' communication

	PPVT Standard Score	PPVT %tile	PPVT Overest.	Verbal Score	Age Learn to Sign	Receptive Skill: ASL	Receptive Skill: SimCom	Receptive Skill: English Sign	Receptive Skill: Speech	Expressive Skill: ASL	Expressive Skill: English Sign	Expressive Skill: SimCom	Prefer Sign vs. Speech	Prefer ASL vs. English Sign
TRT	−.07	−.04	.03	.13	.01	.04	.06	.06	−.10	−.06	−.07	−.07	−.01	.08
PPVT Standard Score	-	.89**	−.49**	.61**	−.04	−.37**	.19	.01	.45**	−.44**	−.11	.14	−.38**	.14
PPVT Percentile	-	-	−.40**	.62**	.02	−.40**	.05	−.03	.41**	−.46**	−.14	.08	−.39**	.18
PPVT Overestimates	-	-	-	−.22*	−.01	.28**	−.01	.11	−.16	.20	.10	.01	.16	.10
Verbal Score	-	-	-	-	.11	−.18	.14	.15	.28**	−.36**	.05	.13	−.22*	.22*
Age Learned to Sign	-	-	-	-	-	−.36**	−.12	−.22*	.23*	−.28**	−.14	.05	−.22*	.24*
ASL Receptive	-	-	-	-	-	-	.18	.30**	−.41**	.79**	.33**	.13	.67**	−.25*
SimCom Receptive	-	-	-	-	-	-	-	.37**	.26*	.01	.34**	.56**	.01	.22*
English Signing Receptive	-	-	-	-	-	-	-	-	.05	.24*	.52**	.26*	.24*	.11
Speech Receptive	-	-	-	-	-	-	-	-	-	−.43**	−.02	.29**	−.57**	.25*
ASL Expressive	-	-	-	-	-	-	-	-	-	-	.25*	.06	.70**	−.36**
English Signing Expressive	-	-	-	-	-	-	-	-	-	-	-	.40**	.23*	.22*
SimCom Expressive	-	-	-	-	-	-	-	-	-	-	-	-	−.06	.30**
Preference for Sign vs. Speech	-	-	-	-	-	-	-	-	-	-	-	-	-	−.35**

Note.

* $p < .05$

** $p < .01$