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Phonological Awareness Abilities of Undergraduate College Students: A Comparison of Students in Related and Unrelated Majors

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Phonological Awareness Abilities of Undergraduate College Students: A Comparison of Students in Related and Unrelated Majors

Abstract

An observational study was conducted to evaluate the differences in the phonological awareness (PA) abilities of undergraduate college students in majors related versus unrelated to PA. In order to participate, students must not have had any formal PA or phonetics instruction at the college level. A total of 116 undergraduate students voluntarily participated in an PA assessment, with results analyzed based upon the following three categories: Communication Sciences and Disorders (CSD) major, education major, and other major. Using non-parametric statistical analysis, there were statistically significant differences in CSD majors, in multiple categories of PA skills, compared to both education majors and other majors prior to any instruction in PA or phonetics.

Keywords: phonological awareness, phonetics, undergraduate college students, speech-language pathology, communication sciences and disorders

Keywords

phonological awareness; phonetics; undergraduate; CSD, SLP, Teacher Education

Cover Page Footnote

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Instructors of undergraduate communication sciences and disorders (CSD) courses provide important foundational content for developing professional clinical skills because these courses include students intending to practice as speech-language pathologists (SLPs) and speech-language pathology assistants (SLP-As). Course content, such as the ability to accurately document a client's speech through phonetic transcription, is necessary and can be developed through coursework and then later applied clinically. Therefore, it is critical that instructors develop phonetics courses with strong outcomes so that students can continue to build their skills throughout training. One example of such coursework is phonetic transcription, wherein students learn to document speech sounds utilizing the International Phonetic Alphabet (IPA). This is typically offered relatively early in the undergraduate sequence.

There is a possible link between phonological awareness (PA) and phonetic transcription. PA involves analyzing components of oral language, which then supports the learning of reading and writing (Robertson & Salter, 2018; Schatschneider et al., 1999; Schuele & Boudreau, 2008). According to Bauman-Waengler and Garcia (2020), PA can be viewed as an umbrella term that encompasses a variety of skills, which can be categorized into three primary areas: word/syllable awareness, onset-rime awareness, and phonemic awareness. These skills involve the blending, isolation, deletion, segmentation, and manipulation of speech and units of speech sounds (e.g., syllables, words) as part of the development of reading and writing (Bauman-Waengler & Garcia, 2020). Phonemic awareness, the awareness of individual speech sounds, is particularly important for phonetic transcription. Using the IPA entails transcribing speech, in which one must be able to isolate, segment, and accurately document words, syllables, and phonemes. Further, one must be able to manipulate phonemes in order to develop appropriate target words for treatment of speech sound disorders (SSDs). In order to accomplish these professional tasks, strong PA skills are required.

SLPs use phonetic transcription when they assess and treat speech sound disorders (SSDs). It is important that an SLP has reliable and accurate transcription skills, as this will impact their assessment results and treatment plans (Bauman-Waengler, 2020). Typically, phonetic transcription is taught in undergraduate courses, and students are expected to maintain and apply these skills in future undergraduate and graduate coursework, as well as in clinical experiences and practice (Crais et al., 2015; Tessel & Grover, 2020). Often, when assessing and treating SSDs, clinicians may further assess and treat a client's PA skills due to the interconnectedness of PA with speech and language, and these clients may be at a higher risk for literacy difficulties (American Speech-Language Hearing Association [ASHA], n.d.; McLeod & Baker, 2017; Schuele & Boudreau, 2008).

SLPs additionally provide an important collaborative role in the educational setting due to their expertise in speech and language (ASHA, 2010; Kamhi et al., 2001; Schuele & Boudreau, 2008; Spencer et al., 2008). With PA serving as a critical component of literacy instruction and development, it is within the scope of practice of SLPs. Elementary education professionals also use PA, and it is important that both professions be competent in this area to collaborate in educational settings (ASHA, n.d.; Spencer et al., 2008; Spencer et al., 2011). For educators, competent PA skills are needed to teach reading strategies (Carroll et al., 2012; Kennedy et al., 2013; Sayeski et al., 2017). SLPs must be competent in these skills for their assessments and

treatment, as well as in their provisions of collaborative services, and they can offer a unique contribution to the curriculum planning in the educational setting (Schuele & Boudreau, 2008).

In order for CSD instructors to design phonetics courses with strong student outcomes wherein students are competent with IPA, they should have an understanding of students' baseline abilities with PA, as this is the foundation for phonetic transcription skills. Phonetics textbooks typically present an overview of concepts such as syllable counting and phoneme isolation (Shriberg, et al., 2019; Small, 2020); it is expected, however, that students will already have these skills and use them in IPA for phonetic transcription. Phonetic transcription requires that one rely solely on what sounds are in the word, and to ignore orthographic spelling, such as recognizing that a word such as "through" has only three IPA symbols, but many more letters. It appears that knowledge of spelling may impact accuracy with PA tasks in adults, such as with identifying phonemes (Scarborough et al., 1998). Therefore, learning more about students' PA skills prior to coursework can help phonetics instructors to understand what areas of PA students may need more explicit practice and instruction.

Review of the Literature

PA Assessment with Undergraduate College Students. While exploring PA skills of undergraduate CSD students it is important to know context as to how students were compared. There is limited evidence regarding the PA skills of undergraduate college students, and most studies have focused on comparisons of those with and without identified disabilities. These students have primarily been evaluated for learning disability, as college students with learning disabilities may have difficulty meeting the reading and writing demands in higher education (Del Tufo & Earle, 2020; Earle & Del Tufo, 2021; Wilson & Lesaux, 2001). Disability assessment is also important for examining PA competency among education majors/professionals and SLP majors/professionals (Carroll et al., 2012; Hall-Mills & Bourgeois, 2008; Hillenbrand, 2017; Moran & Fitch, 2001; Robinson et al., 2011; Sayeski et al., 2017; Spencer et al., 2011; Werfel, 2017; Westerveld & Barton, 2016). Hurford and colleagues (2016) compared the phonological awareness abilities of education majors with non-education majors utilizing a number of subtests from the Comprehensive Test of Phonological Processing (CTOPP). Although the pre-service teachers outperformed the non-education majors, the results were not statistically significant and were within the average range for the normative sample of the CTOPP (Hurford et al., 2016).

There is little published research on the PA skills of undergraduate college students that is not centered on learning disabilities. Further, no studies have compared the PA skills of undergraduate students in education and CSD majors with other undergraduates. Of the few studies located that assessed some level of phonological processing and/or PA skill for undergraduate college-aged students with an unspecified major, both studies recruited a portion of their participants from undergraduate speech-language pathology courses but did not compare them with participants in the group from other majors (Henbest, et al., 2020; Katz & Moore, 2021). Katz and Moore (2021) examined phonological memory, a part of phonological processing, but did not directly assess phonological awareness. Instead, the focus was on word learning and its relationship with acoustic effects. Scarborough and colleagues (1998) studied grapheme to phoneme correspondence of college students from teacher education courses who had already earned at least a bachelor's degree. Interestingly, it appears that adolescent and adult readers may have variable performance

with phonemic awareness that does not always reach a near-perfect score, despite assumptions that they would demonstrate full phonemic skills, as proficient English readers (Scarborough et al., 1998).

PA Assessment of Undergraduate SLP majors and Education Majors. Given the importance of PA skills in the training of phonetic transcription, several studies have examined the PA skills of undergraduate SLP majors. Moran and Fitch (2001) found that students vary in PA ability and note that phonetics instructors should not assume that students have established PA skills. Further, they found that students who scored lowest on the phonemic switching and phonetic reversal tasks also demonstrated the lowest transcription scores. Other explorations of the relationship between PA skills and phonetic transcription in SLP undergraduate students have indicated that these students not only have varying abilities with PA skills, but that they also may need to have awareness of their skill level, and should receive direct instruction in PA to assist with the development of phonetic transcription skills (Hall-Mills et al., 2007, as cited in Hall-Mills & Bourgeois, 2008; Hall-Mills & Bourgeois, 2008; Hillenbrand, 2017; Robinson et al., 2011). On a phoneme counting task administered before taking a phonetics course, SLP majors were less than 50% accurate (Werfel, 2017). However, the varying skills seen in these students indicate there is a need for comparison of these results to same-aged peers from other majors in order to establish if they are similar or different from their peers. Robinson et al. (2011) found that SLP majors had Elision scores that appeared to exceed a normative prediction, while Phoneme Reversal scores were lower than a normative prediction, which indicates the possibility for SLP majors to deviate from their same-aged peers. Based on these findings, identifying if there are any differences in PA abilities between CSD majors compared with other same-aged peers will provide valuable information as to whether PA abilities of CSD majors are truly higher or lower than other undergraduate college students.

An important reason for the comparisons made in the existing literature between SLP students/professionals and education majors/professionals is due to both having PA in pre-professional coursework and their professional roles. It is possible that instruction in phonetics may further develop PA skills in undergraduate students, as there is evidence that once an SLP major has completed phonetics instruction, they outperform undergraduate education majors on PA tasks, but that the undergraduate training still may not be adequate to fully develop PA skills. Westerveld and Barton (2016) compared undergraduate education majors to graduate SLP majors who had already received training in phonetic instruction, with SLP majors outperforming the education majors on all four PA tasks. However, on two measures, specifically, counting the number of sounds in words and identifying the second sound in a word, the master's level SLP students still had low levels of performance, indicating that their prior undergraduate coursework had not provided them with adequate knowledge for the full range of phonemic awareness. Westerveld and Barton concluded that college students in both of these majors need phonemic awareness development through coursework. Kennedy and colleagues (2013) compared education majors to non-education majors and determined that education majors significantly outperformed non-education majors on measures of knowledge and application of PA at their pretest measure. Notably, they included eight SLP major undergraduate students in their group of education majors but did not analyze the SLP majors separately.

In examining comparisons with working professionals, several investigators have found that PA skills among practicing SLPs exceed those of practicing educators (Carroll et al., 2012; Messier & Jackson, 2014; Spencer et al., 2008). The phonemic awareness skill of phoneme segmentation (counting the number of phonemes in a word) was examined in practicing SLPs and educators, with the data then later compared to SLP undergraduate students (Spencer et al., 2008; Spencer et al., 2011). Practicing SLPs outperformed educators, while undergraduate students who had not completed phonetics courses had similar performance to the practicing educators. This suggests that there may be differences with PA skills in undergraduate SLP majors prior to any phonetics coursework from same-aged peers in other majors.

PA Assessment Differences Found in the Literature. Lack of consistency in which parameters of PA were measured in determining the PA skills of undergraduate college students is a primary issue within the literature (see Appendix A). Many investigators only looked at one or two aspects of PA. McBride-Chang (1995) highlighted this issue within PA research with children, wherein several different task types and complexities were administered across studies, though all purported measuring the same general skills. Werfel (2017), who explored the phonemic awareness skills of SLP students, suggested that future research should include more parameters of PA. A variety of tools, including researcher-developed tools, have been utilized for assessment in published reports. It does not appear that some areas, such as counting the number of words in a sentence and production of rhyming words, have been explored with undergraduate students. It is possible that this is due to the assumption that such skills would be well-established for young adults who are experienced readers, but Scarborough et al. (1998) suggested that this may not be the case.

Many of the studies used pencil and paper tasks. While this may be convenient, PA is an auditory task (Bauman-Waengler, 2020, McBride-Chang, 1995). Therefore, providing stimuli via written words, and/or having participants respond with a written word, would not necessarily yield a valid result for PA ability. In fact, Werfel (2017) acknowledged measuring "explicit" phonemic awareness, due to the stimuli being presented orthographically and not auditorily (p. 283). It is notable that the standardized formal tests created to assess PA are designed with auditory stimuli and verbal responses (Robertson & Salter, 2018; Wagner et al., 2013). McBride-Chang (1995) discussed the importance of auditory stimuli and verbal responses in order to accurately assess PA. In sum, auditory means and verbal responses should be used to assess PA when applicable.

Purpose of this Study

A review of the literature identified several knowledge gaps. First, there is lack of evidence regarding the gamut of PA skills, particularly among undergraduate students, regardless of major. Most of the available literature measured a few aspects of PA but did not assess the full range of PA skills. Second, while there have been assessments of SLP students, education students, and undergraduate students in majors unrelated to PA, no one has compared these three groups. Therefore, we developed the following research question: Is there a difference in phonological awareness (PA) skills between non-PA related majors as compared to elementary education majors, and to Communication Sciences and Disorders (CSD) majors (prior to any phonetics and/or phonological awareness coursework)? We hypothesized that undergraduate students who

are in majors related to PA, such as education and CSD, would differ in PA skills compared to undergraduates in unrelated majors, e.g. biology and business.

Methodology

Development of an Assessment Tool for PA. The researchers for this study determined there were two important components for the development of a tool to answer this research question. First, stimuli should be presented orally, given that PA is an auditory skill (Bauman-Waengler, 2020). Many prior studies have utilized written presentation of stimuli either via pencil and paper or an online survey (Messier & Jackson, 2014; Spencer et al., 2008; Spencer et al., 2011; Werfel, 2017), but because the skill of PA is based on perceiving orally presented language, absent from spelling, we presented all stimuli orally. According to McBride-Chang (1995), it is important that stimuli not only be presented orally, but also for the listener to respond verbally, particularly to provide specific phonemic information. Thus, any answers that were not binary (e.g., yes/no, same/different) or a counting task (e.g., number of words in a sentence) were designed for individual delivery with verbal responses.

Second, the researchers established the necessity of developing an assessment tool including all areas under the PA umbrella. While the CTOPP (Wagner et al., 1999) was utilized by several researchers, it is primarily intended for assessing phonological processing, and only addresses a few specific skills within PA, namely those under the category of phonemic awareness. Furthermore, its second edition, the CTOPP-2 (Wagner et al., 2013) no longer contains the subtests of phoneme reversal and segmenting words that were described and utilized by Robinson et al. (2011).

To assess the full PA umbrella, and in order to address internal validity of items by the creation of unvalidated items, previously developed items from standardized tests and from other published research were combined into a single assessment tool. See Appendix B for a description of the 15 subtest items included in the development of a novel PA assessment and how they address the range of PA. The Phonological Awareness Test, Second Edition, Normative Update (PAT-2: NU; Robertson & Salter, 2018) was identified as an established standardized test which provided a broad range of PA tasks. Although it is normed up to age 9;11, the items have already been developed and validated by the test creators. Further, the PAT-2: NU manual indicates that it is highly correlated with the CTOPP-2 for phonological awareness (Robertson & Salter, 2018). Eleven items from the PAT-2:NU (Robertson & Salter, 2018) were combined with two items developed by Moran and Fitch (2001), one item developed by Spencer et al. (2008), and one item from the Test of Language Development: Primary-5th Edition (TOLD: P-5; Newcomer & Hammill, 2019).

Some adaptations based on feedback from pilot assessments were made for the final assessment tool. The Vowel Matching task created by Moran and Fitch (2001) was administered during individual sessions to allow for repeats and time to respond. The target word was spoken, and the matching choices were only presented on the student response form. The Phoneme Counting task (Spencer et al., 2008) was adapted by presenting the words verbally and by removing three of the items due to the variability in which the phonemes could be counted. The Auditory Discrimination task that originated from the TOLD: P-5 was reduced from 38 items to 20 items by randomly

selecting items while retaining the same ratio of foils. The Phoneme Reversal task (Moran & Fitch, 2001) was reduced to 10 items by removing the 10 items that were most frustrating to pilot participants. This final tool, the Phonological Awareness Assessment Tool (PAAT) resulted in a total of 178 items, which could be analyzed by individual subtests and combinations of subtests (see Appendix B).

Regardless of how these items had been administered by the originating authors, all items were pre-recorded into digital audio files created in a sound-proof audiology booth by the primary investigator (PI). This ensured that all participants were given the same auditory stimuli for all items. Items that could be written were done with a small group or individually. Oral responses were provided during individual sessions and were recorded by the first author utilizing the IPA. Additionally, the final component was to have the participants' hearing screened bilaterally at 25dB for 1000, 2000, and 4000 Hz.

To address internal reliability for scoring, a trained graduate assistant who was IRB approved scored all responses for a small random sample of the assessments, providing inter-rater reliability measures of 99% on scoring. Completed assessments were scored twice by two separate trained graduate students to reduce the likelihood of scoring errors. Entry of the data into an Excel spreadsheet was double checked prior to analysis to reduce the likelihood of entry errors.

Participants. All participants were provided with and signed informed consent for research procedures that were approved by the Institutional Review Board. Undergraduate students at a private, religiously affiliated university located in Texas were voluntarily recruited through a variety of undergraduate education courses. Students were recruited from freshman/sophomore level majors' courses offered prior to any instruction regarding PA. Students who completed the entire assessment were entered into a gift card drawing.

In order to be included, students had to be an undergraduate student, report English as a first language or have English proficiency and report no prior PA instruction in a college course. Students indicated their year in school as opposed to credit hours when there was a discrepancy. Participants who self-reported as having a learning disability were not excluded, as they would be included in a typical classroom, and these data were further analyzed for comparisons.

Procedure. To answer the research question, an exploratory/comparative design was employed, as there was no intervention and only between group differences were tested (Binkley, 2021; Drummond & Murphey-Reyes, 2018; Portney, 2020). The research procedure and PA Assessment Tool were approved by the Internal Review Board associated with the researchers, and with an affiliation agreement of a second Internal Review Board for the university where the participants attended.

The newly developed PAAT was utilized, totaling 15 separate tasks, and participants were additionally administered a pure-tone hearing screening. Students who did not pass at all frequencies of the hearing screening were immediately informed of the results but were not excluded from the study. Digital recordings for all 15 subtest stimuli were presented to all participants using the same Bluetooth speaker. Items were played once, and then replayed if requested. For students who received group administration of subtest items 1-5, individual follow

up within a few weeks completed administration of the remaining items. For students who had not completed any items, all items were administered during an individual session. The total time for a participant to complete both assessments and the hearing screen was 30-40 minutes.

A total of 119 participants met inclusion requirements and participated in all portions of the assessments. Of the 119 participants, 60 were classified as freshmen, 49 sophomores, 7 juniors, and 3 seniors. The three seniors were excluded, since they were not comparable in classification to the entry-level CSD majors or education majors. Thus, the final sample was 116. See Table 1 for demographic information. The median age for all three major groups was 19, and the total range of ages for the entire participant group was 17 to 21.

Table 1

Participant Demographics

Student Major	Student Classification			Total Number
	Freshman	Sophomore	Junior	
Communication Sciences and Disorders (CSD) Majors	16	9	4	29
Education Majors	3	24	1	28
Other Majors (e.g.: Business, Biology, Kinesiology, Graphic Design)	41	16	2	59

Statistical Analysis. The PAAT was scored and analyzed with SPSS Version 27 (IBM Corporation, 2020). Results were analyzed by individual subtest (13 total subtests), as well as in combination by grouping: overall word/syllable awareness score (segmenting sentences, segmenting syllables, blending syllables), overall onset-rime awareness score (recognition of rhyming words, rhyming production), overall phonemic awareness score (phoneme counting, auditory discrimination, blending phonemes, phoneme segmentation, phoneme isolation, vowel matching, phoneme deletion, phoneme reversal), and overall phonological awareness score (total of all items).

Because college students with learning disabilities may score lower on phonological awareness tasks (Del Tufo & Earle, 2020; Earle & Del Tufo, 2021; Wilson & Lesaux, 2001), a comparison with those who did not report learning disabilities was conducted. Mann-Whitney U and Median Tests detected no difference between those who reported a learning disability and those who reported no learning disability on any subtest or grouping of subtests (see Table 2). Therefore, all further statistical analyses included all 116 participants, regardless of reported learning disability status.

Table 2

Comparisons of Students with and without Reported Learning Disabilities

PA Assessment Category (possible total score)	Median Test (Significance)	Mann-Whitney U Test (Significance)
Overall Phonological Awareness (178)	.335	.407
Overall Syllable Awareness (30)	.845	1.000
Overall Onset-Rime Awareness (20)	*	.117
Overall Phonemic Awareness (128)	.219	.432
Number of Words in Sentence (10)	*	.921
Number of Syllables in Word (10)	*	.610
Identification of Rhyming Words (10)	*	.788
Counting Phonemes in Words (18)	.511	.233
Auditory Discrimination between Words (20)	.630	.745
Blending Syllables (10)	1.000	.810
Rhyming Production (10)	*	.096
Blending Phonemes (10)	*	.167
Phoneme Segmentation (10)	.861	.470
Phoneme Isolation (Beginning Phoneme) (10)	.456	.423
Phoneme Isolation (Final Phoneme) (10)	.653	.627
Phoneme Isolation (Medial Phoneme) (10)	*	.571
Overall Phoneme Isolation Score (30)	.062	.208
Vowel Matching (20)	.997	.614
Phoneme Deletion (10)	*	.209
Phoneme Reversal (10)	.563	.474

Note. *SPSS unable to compute

Results

Participants were categorized as: CSD major, education major (including all specialty areas), and other major. Scores were analyzed three ways: individual subtest score level, combined category score (syllable awareness, onset-rime awareness, phonemic awareness, overall phoneme isolation), and by an overall PA score for all items administered. This resulted in 20 dependent variables. The median, minimum, and maximum scores for each category by group can be seen in Appendix C.

An Analysis of Variance (ANOVA) was attempted, but use of the Kolmogorov-Smirnov Test of Normality determined that the data were not normally distributed, and assumptions for parametric testing were not met. The strong negative skew and kurtosis observed are likely artifacts of ceiling effects. Next, nonparametric measures were utilized to analyze differences between the three

groups using Kruskal Wallis Test and the Median Test. Across all 20 dependent variables, all three groups (CSD, education, other major) were compared. See Table 3 for overall results and Table 4 for pairwise comparisons.

Table 3

Nonparametric Testing Results

PA Assessment Category	Kruskal Wallis (Significance)	Median Test (Significance)
Overall Phonological Awareness Score	.630	.975
Overall Syllable Awareness Score	**.030**	**.034**
Overall Onset-Rime Awareness Score	.403	*
Overall Phonemic Awareness Score	.639	.990
Number of Words in Sentence	**.055**	*
Number of Syllables in Word	.159	*
Identification of Rhyming Words	.284	*
Counting Phonemes in Words	.384	.791
Auditory Discrimination Between Words	.062	.121
Blending Syllables	.849	.848
Rhyming Production	.619	*
Blending Phonemes	.190	*
Phoneme Segmentation	.197	.478
Phoneme Isolation (beginning phoneme)	**.010**	**.003**
Phoneme Isolation (final phoneme)	.973	.922
Phoneme Isolation (medial phoneme)	.460	*
Overall Phoneme Isolation Score	.260	**.017**
Vowel Matching	.637	.502
Phoneme Deletion	.240	*
Phoneme Reversal	.192	.386

Note. *SPSS unable to compute

Table 4

Pairwise Comparisons

PA Assessment Area	Statistical Analysis	CSD Majors-Education Majors	CSD Majors-Other Majors	Education Majors-Other Majors
Overall Syllable Score	Kruskal-Wallis	.484	**.013**	.098
Phoneme Isolation (beginning phoneme)	Kruskal-Wallis	**.003**	**.019**	.288
Overall Phoneme Isolation Score	Median Test	**.004**	.057	.151
Counting Words in Sentences	Mann Whitney U	.231	**.018**	.297

From these analyses, there were three significant differences found in the dependent variables: Overall Syllable Score, Isolation of Initial Phoneme subtest, and Overall Phoneme Isolation Score. There was a significant difference between the distributions of the scores in Overall Syllable Score, $H(2) = 6.998$, $p = .030$. A pairwise comparison showed the differences were only significant ($p = .013$) for CSD (*Mdn* = 29, *M* = 29, *Min* = 24) compared to other majors (*Mdn* = 29, *M* = 28.24, *Min* = 21), and no difference was found between other groups. Additionally, there were differences with the subtest of Isolation of Beginning Phoneme, $H(2) = 9.220$, $p = .010$, with pairwise comparisons indicating CSD majors (*Mdn* = 10) scored higher than education majors (*Mdn* = 9; $p = .003$) and other majors (*Mdn* = 9; $p = .019$). This was not the case when comparing education majors to other majors. Use of the Median Test provided further insight into the comparison between the three groups. There was a difference ($p = .017$), with pairwise comparisons revealing a significant difference ($p = .004$) between the median of CSD majors (*Mdn* = 29) and education majors (*Mdn* = 28). All three of these findings indicate that CSD majors, who have not yet been introduced to phonetics or phonological awareness, performed higher than education majors and other majors in these skills.

A fourth area approached statistical significance ($p = .055$): the subtest of Counting Words in Sentences. Pairwise comparisons revealed that the distributions were different for CSD majors compared to other majors, with other majors performing worse (*Mdn* =10, *M* = 9.27, *Min*= 3) than CSD majors (*Mdn* = 10, mean = 9.86, *Min* = 9; $U = 642.50$, $p = .018$). For this subtest, there was no statistically significant difference in variance for education majors versus other majors or versus CSD majors.

Discussion

This study compared a wide range of PA skills between undergraduate college students who are in PA-related majors to those who are not. We also learned more about the average PA skill level among undergraduate college students in general. This study found that CSD majors outperformed their peers prior to any direct instruction in PA, in a few specific areas of PA. This may suggest that CSD majors begin their coursework with a slightly stronger PA foundation in some areas than their same-aged peers in other majors. It may be that students interested in the field of CSD are drawn to the field due to personal attentiveness to speech sounds. The PA area that all three groups performed similarly in was onset-rime production, which was assessed through two rhyming tasks.

Differences in the Overall Syllable Score (i.e. the combination of three subtests: Number of Words in Sentences, Counting Syllables, Blending Syllables) were likely due to differences seen between CSD majors and other majors in the area of Counting Words in Sentences. During the assessment of these tasks, the PI noted that some students would express confusion about how to count word breaks in the presence of possessive nouns and contractions. This specific task, which was derived from the segmentation subtest of the PAT-2 NU (Robertson & Salter, 2018), is normed for up to ages nine years, eleven months and was delivered as an individual subtest, so comparisons to the normative sample cannot be made. No other study was found to have assessed this specific area of PA, likely because of the assumption that undergraduate college students would all be proficient. While the overall group median was 10, which is the maximum possible score, the overall group mean score was 9.51, with a minimum score of 3, and 28.4% of the undergraduate students scored less than 10 on this item. Although this is considered to be the simplest PA task, these results indicate that even basic PA skills may need explicit instruction and training.

Another area in which CSD majors outperformed their same-aged peers was in phoneme isolation, specifically in isolation of the beginning phoneme, as well as for the overall score for isolation of initial, medial, and final phonemes. This is particularly interesting as CSD students must use this skill in a phonetics course to address course outcomes, such as phonetic transcription. This indicates that CSD majors may begin at a slight advantage over same-aged peers in phoneme isolation. However, on phoneme segmentation tasks, CSD majors did not perform better than same-aged peers prior to direct instruction. This is likely due to the complexity of counting phonemes that do not have a 1:1 grapheme correspondence, which indicates a need for direct and explicit training.

In looking at the median scores for all participants combined, it was evident in which PA areas all undergraduate students were approaching competency: Counting Words in Sentences, Syllable Counting, Rhyme Identification, Rhyme Production, Phoneme Blending, Phoneme Isolation of the Medial Consonant, and Phoneme Deletion. Conversely, Phoneme Counting scores were the least accurate. The combined median score (10) was much lower than the possible score (18). This was similar to results from the Phoneme Segmentation subtest with a combined median score of 6 out of a possible score of 10. Students also had more difficulty on the phoneme reversal task (combined median 7, possible score 10), and the Vowel Matching task (combined median 16, possible score 20). Thus, it appears that phonemic awareness is the most challenging area of the PA construct for undergraduate students regardless of major, which is the focus area of instruction for a phonetics course.

In regard to the participant demographics, it is notable that CSD majors and education majors were over 96% female, whereas the other majors were only 61% female. There is some indication that adult females may outperform adult males on the PA tasks of elision and blending on the CTOPP (Hurford et al., 2016). While this does differ between CSD majors and other majors, data from the American Speech-Language-Hearing Association (2020) indicate that over 95% of practicing SLPs are female. Therefore, this gender distribution closely represents demographics for both SLP majors and SLPs.

The results of this study indicate that undergraduate students, including CSD majors, begin coursework without full competency in PA skills. This means that a phonetics instructor cannot assume foundational knowledge when developing and designing a phonetics course. It is possible that the gaps in student knowledge about PA may be contributing to the challenges they experience with acquiring phonetic transcription skills. For example, if students cannot count syllables in a word, then asking students to identify the stressed syllable in a word for accurate transcription may prove more challenging than anticipated. Encouragingly, the results of this study also found that CSD students may have some inherent strengths in PA that their peers in other majors may not. This provides an opportunity for phonetics instructors to help students recognize and use these strengths as a foundation to build phonetic transcription skills, while still recognizing areas where students may need explicit instruction for foundational knowledge.

Limitations

A limitation of this study is that the participants all were from a single university, which may not represent peers in other regions of the country and could limit generalizability. A second limitation

is the relatively small sample, which was limited by the enrollment numbers for the introductory CSD and education courses. Despite these limitations, the sample size and lack of institutional variation is similar to other reports exploring PA skills in undergraduate students. As mentioned, another limitation is that the education majors and CSD majors were predominantly female, while the gender of participants from other majors were more evenly distributed. It is possible that some of the differences found between the CSD major, and the other major group could be related to gender differences.

Future Directions

Due to the ceiling effects (i.e. range restriction) of many of the subtest scores, strong negative skew impacted the ability to compare groups. The subtest items for this study were selected as a piloting of a comprehensive PA assessment tool, so that more could be learned about what items were challenging for undergraduate students. Future studies could reduce the subtest items to only those which had the most variation in this sample, as well as to offer more challenging items to reduce the likelihood of ceiling effects. Future studies could assess students from a variety of universities across the United States in order to increase generalizability.

Conclusions

This study represents the first of its kind to explore a wide range of PA skills for undergraduate students and to compare skills across CSD majors, education majors, and those outside of these two majors. Our hypothesis was that there would be some differences between these groups, which we did find in the areas of Overall Syllable Score, Beginning Phoneme Isolation Score, and Overall Phoneme Isolation Score. This preliminary study indicates the need for more research to explore the PA skills of undergraduate students, particularly those who are in majors related to PA to inform instructors about the baseline skill set for students. While students earned maximal scores for many subtest items, there were other areas that appear to need direct and explicit instruction, particularly in the area of phonemic awareness. Understanding students' knowledge gaps, rather than building coursework based upon the assumption that the skills are present, could have positive effects on undergraduate student learning and integration of course concepts.

Disclosures

The authors have no relevant financial relationships to disclose. As a disclosure of non-financial relationships, the researchers disclose that the research herein was collected and analyzed as part of a dissertation to fulfill a Doctor of Philosophy in Health Sciences requirement for the first author, with the other authors serving on the dissertation committee.

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Appendix A

Phonological Awareness Tasks Assessed in the Literature

Phonological Awareness Task (Bauman-Waengler & Garcia, 2020)	**Example of Task** (Bauman-Waengler & Garcia, 2020)	**Name of PA Activity and Cited Study**	**Delivery Method of PA Activity**
Word/Syllable Awareness and Segmenting			
Segmenting words in sentences	How many words in sentence		
Syllable Awareness	How many syllables in word	• "indicate number of syllables in given words"; Messier & Jackson, 2014 • "Syllable Identification"; Carroll et al., 2012 • "Syllable Identification"; Westerveld et al., 2016; Westerveld & Barton, 2017	• 5 items ranging from 1-5 syllables; on Survey Monkey • Spoken words, participants recorded answer on paper • Same as Carroll et al., 2012 but with multiple choice options
Syllable Completion	Compound words—ask them to complete		
Syllable identification	Compound words—compare 2, which are the same (ex: football/baseball)		
Syllable Blending	Compound words/2 syllable—put two words together to make a word (win dow/window)	• "Blending"; Del Tufo & Earle, 2020; Earle & Del Tufo, 2021; Hurford et al., 2016	• CTOPP
Syllable Deletion	Compound words/two syllable words to create new (jellyfish/fish)	• "Elision"; Del Tufo & Earle, 2020, Earle & Del Tufo, 2021; Hurford et al., 2016; Robinson et al., 2011	• CTOPP

Onset-Rime Awareness and Production			
Recognition of rhyming words	Do these two words rhyme?	• "rhyme matching"; Carroll et al., 2013; Westerveld & Barton, 2017	• Read ten words and match four pairs of rhyming words
Recognition of onset-rime words that do not match	1 out of 3-4 words that do not rhyme	• "odd rhyme"; Hillenbrand, 2017	• From 4 non-English words, find one that does not rhyme with others
Producing rhyming words	Real or non-word that rhymes with a word		
Phonemic Awareness Tasks			
Identifying Phonemes			
Phoneme detection, same v. different	Which of these words has a different first sound?	• "alliteration awareness"; Carroll et al., 2012; Westerveld & Barton, 2017	• Read 9 words and match those starting with same sound but different graphemes
		• "odd vowel sound, odd final sound, odd initial sound"; Hillenbrand, 2017	• Find odd vowel/final/initial sound in list of words
		• "similar word endings"; Kennedy et al., 2013	• Find word in row that ends with same sound as presented word; paper task
Phoneme matching the same	Which word begins with the same sound?	• "vowel matching": Moran & Fitch, 2001	• 20 sets of words; students listen to word and circle word from choice with same vowel sound
		• "phoneme identification": Spencer et al. 2008; Spencer et al., 2011	• Pencil and paper task of matching a selected sound from a word with choice of 4 words
		• "phoneme identification"; Messier & Jackson, 2014	• Similar to Spencer et al, 2008; on Survey Monkey

Isolating phonemes/blending phonemes

Phoneme Isolation	Which sound do you hear at the beginning of…at the end of…	• "phoneme isolation": Spencer et al. 2008; Spencer et al. 2011	• Pencil and paper task of giving letter from a word that represents the requested sound (i.e.: third speech sound)
		• "second sound identification"; Carroll et al., 2012	• Identification of second sound in six spoken words with written response for letter or combination of letters
		• "final sound identification"; Carroll et al., 2012	• Identification of last sound in six spoken words with written response for letter or combination of letters
		• "second sound identification, final sound identification"; Westerveld et al., 2016; Westerveld & Barton, 2017	• Same as Carroll et al., 2012, but with multiple choice options
		• "detect k/s"; Hillenbrand, 2017	• from phrase in unfamiliar language, detect k/s phoneme presence
		• "identification of phoneme"; Kennedy et al., 2013	• Ex: what is the third phoneme in the word?; paper task
Phoneme segmentation	How many sounds do you hear in this word/what sounds do you hear in this word?	• "phoneme segmentation": Spencer et al. 2008; Spencer et al. 2011; Werfel, 2017; Henbest et al., 2020	• 21 words presented on paper, separated by easy versus hard
		• "phoneme segmentation"; Messier & Jackson, 2014	• 27 words similar to Spencer et al. 2008; on Survey Monkey
		• "Phonemic awareness task"; Henbest et al., 2020	• Phoneme identification task as created by Spencer et al. (2008)
		• "phoneme counting": Moran & Fitch, 2001; Hall-Mills et al., 2007	• List of 20 words written and heard on recording; count number of sounds and record on paper

		• "Segmenting Words": Robinson et al., 2011; Hurford et al., 2017	• CTOPP
		• "phoneme identification"; Carroll et al., 2012	• Record number of sounds from 10 spoken words
		• "phoneme identification"; Westerveld et al., 2016; Westerveld & Barton, 2017	• Same as Carroll et al., 2012, but with multiple choice options
		• "Counting"; Hillenbrand, 2017	• Count number of speech sounds in word
		• "number of phonemes"; Kennedy et al., 2013	• Identify number of phonemes in single syllable word; paper task
Phoneme blending	Can you put these sounds together to make a word?	• "Blending"; Del Tufo & Earle, 2020, Earle & Del Tufo, 2021; Hurford et al., 2016	• CTOPP
Manipulating phonemes			
Phoneme deletion	What would the word "moon" be without "n"?	• "Elision"; Del Tufo & Earle, 2020, Earle & Del Tufo, 2021; Hurford et al., 2016; Robinson et al., 2011	• CTOPP
		• "Phoneme Deletion Task"; Wilson & Lesaux, 2001	• Task created by Snowling et al., 1997, as cited in Wilson & Lesaux, 2001
Phoneme manipulation	What would the word be if you changed the beginning and end sound around (cap/pack)	• "Phonetic Reversal": Moran & Fitch, 2001; Hall-Mills et al., 2007; Hall-Mills & Bourgeois, 2008	• List of 20 written words; students write down word made by reversing the sounds
		• "Phoneme reversal": Robinson et al., 2011; Hurford et al., 2016	• CTOPP
		• "reversal, sound substitution": Hillenbrand, 2017	• Reverse of first and last sounds of word; vowel sound presented, and then consonants instructed to add to word
		• "word reversal"; Kennedy et al., 2013	• Reverse the order of sounds in word; paper task

Additional Tasks Assessed	Example of Task	Studies Cited	Delivery Method
Spelling	Real word and not real word	• "spelling"; Hillenbrand, 2017 • "real world spelling, pseudoword spelling"; Hall-Mills et al., 2007, Hall-Mills & Bourgeois, 2008	• 20 words that are commonly misspelled and challenging • Researcher-made tasks
Spoonerism Repair/ Exchange	(toin coss-coin toss)	• "phoneme switching"; Moran & Fitch, 2001; Hall-Mills et al., 2007 • "Spoonerisms"; Wilson & Lesaux, 2001 • "Spoonerism Repair"; Hillenbrand, 2017	• 20 two-word phrases, transposing first phoneme of each word; written response • Task created by Snowling et al., 1997, as cited in Wilson & Lesaux, 2001 • Listener fixes to intended utterance
Stress Pattern	"re-FER"	• "odd stress pattern"; Hillenbrand, 2017	• From list, find different stress pattern
Grapheme to phoneme correspondence	Underline the sounds and count the number of sounds in a word Produce a sound(s) associated with the letter/letter combination	• "Graphophonemic segmentation task"; Scarborough et al, 1998 • "Phoneme-grapheme correspondence assessment"; Sayeski et al., 2017	• Pencil and paper task created by researchers • Individual, oral assessment

Appendix B

Phonological Awareness Assessment Tool (Binkley, 2021)

Phonological Awareness Task *(Bauman-Waengler & Garcia, 2020)*	**Example** (Bauman-Waengler & Garcia, 2020)	**Subtest Addressing Task/Original Source/Adaptations**
Word/Syllable Awareness and Segmenting		
Segmenting words in sentences	How many words in sentence	PAT-2: segmentation of sentences* *(ADAPT: oral presentation; student writes number on answer key)*
Syllable Awareness	How many syllables in word	PAT-2: segmentation of syllables* *(ADAPT: oral presentation; student writes number on answer key)*
Syllable Blending	Compound words/2 syllable—put two words together to make a word (win dow/window)	PAT-2: syllable blending
Onset-Rime Awareness and Production		
Recognition of rhyming words	Do these two words rhyme?	PAT-2: rhyming discrimination* *(ADAPT: oral presentation; student circles Y/N on answer key)*
Producing rhyming words	Real or non-word that rhymes with simple one-syllable word	PAT-2: rhyming production

Phonemic Awareness Tasks		
Identifying Phonemes		
Phoneme detection, same v. different	Which of these words has a different first sound?	TOLD-P:5 word matching task* (*ADAPT: student circles same/different; Reduced number of items to 20, with same proportion of foils. Removed 3 items that have less distinction due to southern dialect prior to selecting items randomly. Used app to randomly select items, keeping same ratio of foils.)*
Phoneme matching the same	Which word begins with the same sound?	Moran & Fitch vowel matching task *(ADAPT: individual administration--orally read with choice of 4 words on answer key to circle)*
Isolating phonemes/blending phonemes		
Isolating initial phoneme then final phoneme	Which sound do you hear at the beginning of…at the end of…	PAT-2: isolation of initial, final, medial
Phoneme segmentation	How many sounds do you hear in this word/what sounds do you hear in this word?	Words from Spencer et al., 2008* (*ADAPT: oral presentation of words; have students write number on answer key; removed 3 items that are challenging for a trained SLP to accurately identify number of phonemes due to syllabic possibilities)* PAT-2: phoneme segmentation
Phoneme blending	Can you put these sounds together to make a word?	PAT-2: phoneme blending

Manipulating phonemes		
Phoneme deletion	What would the word "moon" be without "n"?	PAT-2: deletion of phonemes
Phoneme manipulation	What would the word be if you changed the beginning and end sound around (cap/pack)	Moran & Fitch: phonetic reversal task *(ADAPT: individual administration 10/20 items based upon frustration of participants of pilot administration—orally presented and respond orally)*

Note.*indicates group administration is possible

Appendix C

Median, Minimum, and Maximum Scores by Category and Group

PA Assessment Category (possible total score)	CSD Majors Median Score	Education Majors Median Score	Other Majors Median Score	CSD Majors Min-Max Score	Education Majors Min-Max Score	Other Majors Min-Max Score
Overall Phonological Awareness (178)	154	152	152	127-169	109-168	93-169
Overall Syllable Awareness (30)	29	29	29	24-30	25-30	21-30
Overall Onset-Rime Awareness (20)	20	19.50	20	18-20	17-20	17-20
Overall Phonemic Awareness (128)	104	102	103	78-119	63-119	53-121
Number of Words in Sentence (10)	10	10	10	9-10	8-10	3-10
Number of Syllables in Word (10)	10	10	10	5-10	5-10	5-10
Identification of Rhyming Words (10)	10	10	10	10-10	9-10	9-10
Counting Phonemes in Words (18)	10	11	10	2-14	4-13	1-14
Auditory Discrimination between Words (20)	20	19	19	15-20	11-20	15-20
Blending Syllables (10)	10	10	9	9-10	9-10	9-10
Rhyming Production (10)	10	10	10	8-10	7-10	7-10
Blending Phonemes (10)	10	9.4	10	8-10	7-10	6-10
Phoneme Segmentation (10)	8	6	6	3-10	1-10	0-10
Phoneme Isolation (Beginning Phoneme) (10)	10	9	9	1-10	3-10	1-10
Phoneme Isolation (Final Phoneme) (10)	9	9	9	5-10	4-10	5-10
Phoneme Isolation (Medial Phoneme) (10)	10	10	10	3-10	2-10	2-10
Overall Phoneme Isolation Score (30)	29	28	28	17-30	12-30	10-30
Vowel Matching (20)	15	15.50	16	8-20	7-19	4-20
Phoneme Deletion (10)	10	10	10	5-10	8-10	4-10
Phoneme Reversal (10)	6	6	7	1-10	0-10	0-10