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A Survey of Speech Sound Productions in Children With Visual Impairments

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Abstract

This survey addressed a twofold need: first, research into speech sound productions in children with visual impairments and, second, evidence upon which speech-language pathologists might base interventions for children with visual impairments. Fifteen speech-language pathologists responded to a survey about speech sound productions in caseload children with visual impairments. Respondents reported the speech characteristics of 46 children, their coexisting medical diagnoses and developmental conditions, the nature of their visual impairments, and therapy approaches used. Children and teens with visual impairments demonstrated speech sound production errors. It is not conclusive that errors resulted from having visual impairments. Respondents reported effective speech treatment techniques. This study contributes a detailed report of speech sound productions in children who, despite a diversity of coexisting diagnoses, had visual impairment in common. Findings provide a point of reference regarding speech sound productions in children with visual impairments, as well as efficacious treatments.

Keywords

articulation, speech/sound, disorders, communication, blind/low vision, exceptionalities, developmental, intervention strategies, survey, research, service delivery, speech-language pathologists (SLPs)

This article reports the results of a survey of the characteristics of a sample of children and teens with visual impairments (VIs) who experienced difficulty with speech sound productions. The speech-language pathologists (SLPs) who treated these youths provided the survey responses.

This study addressed the need for additional research into the nature of speech sound productions in children with VI and the need for clinical evidence upon which SLPs might base interventions. There is some current clinical research that describes the nature of children's speech sound productions in the setting of VI but little practical research that documents how SLPs provide therapy to improve speech sound productions in children with VI. As such, there is little evidence that informs SLPs about effective practices. The National Federation of the Blind (2016) reported that the percentage of youth in the United States younger than age 20 who have some degree of visual disability is about 2.4% (694,300 children).

Speech Sound Production in Children With VI

Studies of speech sound productions in children with VI offered inconsistent results. Perhaps one reason for the contradictory results is, as Elstner (1983) observed, that there really is no homogeneous population of persons with VI. Differences in speech sound production capabilities in persons with VI can be related to the etiologies for VI, age of onset of VI, severity of impairment, and comorbid conditions. These many factors can result in mixed arrays of individual differences.

Research dating back several decades indicated that VI may have a negative effect on children's speech sound productions (as reviewed by Brouwer et al., 2015). Brouwer et al. reported that LeZak and Starbuck (1964) found that 37% of 173 children with VI exhibited speech disorders. Lewis (1975) noted that prespeech sound productions in the setting of VI consisted of fewer labial sounds. Elstner (1983) reported various studies that documented phonological disorders in older children with VI. House (2000) compared the speech of 12 adults with VI with 12 matched sighted peers. The participants with VI scored significantly lower on standardized speech measures and exhibited a greater number of visible errors in

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articulatory placement. James and Stojanovik (2007) reported that articulation skills in a sample of eight children with VI between the ages of 7 and 17 were in approximately the lower third of performance abilities. Ménard, Dupont, Baum, and Aubin (2009) suggested that a lack of access to visual information might induce differences in the control of the articulators.

Mills (1987) reported that children with VI were slower in the acquisition of speech sounds and had differing error patterns when compared with their sighted peers. Mills concluded that lack of visual input did not make the observed children more susceptible to speech sound production errors. Mills reported that imprecision of articulation was not more likely to occur for those phonemes that are visible when uttered. The missing visual input for how to place the articulators to produce phonemes did not have a negative effect. However, because of the articulatory imprecision apparent in the children with VI, Mills concluded that the lack of visual input did hinder the children's overall speech acquisition process.

Brouwer et al. (2015) found that within a sample of children with VI a greater number had received therapy for speech sound production than expected based on the prevalence of speech sound disorder (SSD) in the general population. Of 120 children and adolescents with VI, the percentage that received speech sound production treatment at the time of the study (29%) plus those who had previously received treatment (42%) far exceed the National Institute on Deafness and Other Communication Disorders (NIDCD; 2010) SSD prevalence figure of 8% to 9% for children in the general population.

In summary, research reported that children with VI may develop speech sound production skills differently than sighted children, but the research did not identify a strong link between VI and SSD. Studies did not identify a linguistic, phonological, or motor basis for SSD, nor was any specific interaction between these precursors confirmed.

Multiple Impairments That Coexist With VI

VI commonly is associated with other impairments or disorders. Batshaw, Roizen, and Pellegrino (2007) reported that "more than half of children with severe intellectual disability and one quarter of children with mild intellectual disability have sensory impairments, of which vision impairments, especially strabismus and refractive errors, are the most common" (p. 252). Children with VI may have coexisting cerebral palsy (Cooper & Cooper, 2016), autism, genetic disorders, infections of the nervous system (meningitis, encephalitis), metabolic disorders, disorders of growth and development, or acquired brain injury, all of which can underlie dysarthria, apraxia, or SSD and impair language development. These coexisting conditions may affect the function of the ocular structures and functions (e.g., as in retinopathy of prematurity, nystagmus) or may lead to cortical vision impairments (e.g., as in homonymous hemianopsia).

Numerous genetic syndromes give rise to vision abnormalities (Batshaw et al., 2007). Many affected children have dysmorphic facial features, impaired movements of the muscles of the eyes, retinal abnormalities, cataracts, cloudy cornea, extreme myopia, retinitis pigmentosa, and dislocation of the lens. Metabolic disorders or disorders of growth and development may cause progressive decline in vision, intellect, and/or motor functioning (Batshaw et al., 2007; U.S. National Library of Medicine, 2014).

Research Problems and Significance

A primary concern is that research is lacking on whether certain speech sound production characteristics are common in children with VI. The reports of the SLPs who treat children with VI would be a valuable source of data on these characteristics.

Another concern is that there is sparse information on how SLPs provide speech interventions for children with VI and few guidelines for suggested practices. Studies have investigated SLPs' preparedness to provide services for children with VI. House and Davidson's (2000) survey of SLPs reported that a small portion of SLPs reported competence with VI. While 69% of the sample had provided services for children with VI, 49% percent reported not having any education about VI and 59% did not feel knowledgeable about children with VI. Brouwer, Gordon-Pershey, and Warkenthien (2013) conducted semistructured telephone interviews with 10 SLPs who serviced children with VI. Interviewees indicated that they never received speech and language training specific to the VI population. The SLPs developed skills on an ad hoc basis, by trying out methods and seeing what worked. They attended professional development events offered in the disciplines of special education and the education of the blind and visually impaired and collaborated with other service professionals to develop their interventions.

A third concern is whether the reports of the study participants, who were SLPs who treated children with VI for deficits in speech sound productions, could substantiate whether a lack of visual input contributed to their caseload children's speech sound productions. The perceptions of these service providers could contribute to a description of the effects of VI on children's speech sound productions.

Research Questions

This study used survey data reported by SLPs to answer the following research questions:

Research Question 1: What are the characteristics of speech sound production in children with VI who are serviced by SLPs?
Research Question 2: What treatment approaches do SLPs report as promoting successful remediation of speech sound production errors in children with VI?
Research Question 3: Do SLPs report evidence that would suggest that a lack of visual input appeared related to speech sound production disturbances in children with VI?

Method

The Institutional Review Board for the Use of Human Subjects in Research of the University of South Dakota approved this study.

Participants

Via email, the third author contacted 20 directors of state schools for children with VI in Alabama, Arkansas, California, Hawaii, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, New York, North Dakota, Pennsylvania, South Carolina, Tennessee, Utah, Vermont, Virginia, and Wisconsin. These states were chosen due to the online availability of information on how to contact the state schools for children with VI. The investigator asked directors to forward the survey to their staff SLPs. In addition, the investigator sent the survey to 16 SLPs who attended the Brouwer et al. (2013) American Speech-Language-Hearing Association (ASHA) convention presentation on SLP practices for children with VI and provided their email addresses, and sent the survey directly to one SLP who serviced children with VI. There were thus 37 attempts to obtain responses. The email contained a link to the online survey. The investigators sent one follow-up email to all potential respondents who had not completed the survey within 1 month of the initial contact.

Instrumentation

The appendix provides the 26 questions. A 10-min training video on how to complete the survey was posted on Youtube.com. Training emphasized that responses should maintain client confidentiality and not provide information that would identify clients. Survey questions allowed each respondent to report on each individual caseload child with VI. Each completed survey response was similar to a status report on an individual child. Each participant responded to the survey as many times as was needed to report on each caseload child, one at a time. Each SLP was given the opportunity to report on up to 50 children and given US$5 compensation per child reported, funded by the third author's research budget. The survey software stored the identifying information needed to send compensation in separate files, without any linkage to the survey responses. Twenty questions were forced-choice and six were open-ended with space for a response of up to 1,000 characters. There was no time limit for completing the survey and participants could log out and return. Access remained open for about 90 days.

Definitions for the severity of VI used in the survey were taken from previous research by Brouwer et al. (2015), based on the International Statistical Classification of Diseases and Related Health Problems (ICD-9; World Health Organization, 2004), the American Optometric Association guidelines (2007, p. 71), and the Individuals With Disabilities Education Act (IDEA; 2004). The survey respondents reported a degree of severity of VI for each child based on the following definitions:

- Low Vision: (20/60 to 20/200): A moderate VI; not necessarily limited to distance vision. Includes difficulty reading at a normal viewing distance and seeing details.
- Legally Blind or Severe Low Vision: (20/200 to 20/500): Gross orientation and mobility are generally adequate, but difficulty seeing traffic signs, bus numbers, and so forth. Reading requires high power magnifiers and/or very short reading distances.
- Blind: (20/500 to no light perception): Problems with visual orientation and mobility; vision is unreliable except under ideal circumstances, or possibly no light perception.
- Functions at the Definition of Blindness (FDB): Visual functioning is reduced by brain injury or dysfunction. Visual acuity is not possible to determine using the Snellen Chart (Snellen, 1862)

Results

The online survey yielded de-identified responses. The number of respondents is based on the number of discrete Internet Protocol (IP) addresses shown in the survey response report. There were 15 unique IP addresses, presumably 15 unique SLPs, that furnished reports on 46 children. The minimum number of children reported on per SLP was one; the maximum number was nine. With 26 responses possible for each of the 46 children, the survey had the potential to yield 1,196 data points. Descriptive data were computed as the frequencies of response for each forced-choice item. The responses to the open-ended items were transcribed and analyzed for their content.

The 26 survey questions were grouped into five segments related to the research questions:

Table 1. Number of Speech Sound Production Errors.

Survey question	Number of responses												
7. Speech errors	0-4 errors			5-8 errors			9+ errors			Generally nonverbal			
	25			8			8			5			
8. and 9. Sounds misarticulated greater than 50% of the time and inappropriate for age	/p/	/m/	/h/	/n/	/w/	/b/	/k/	/g/	/d/	/t/	/ŋ/	/f/	
	9	6	5	6	4	6	8	9	3	6	8	11	
	/j/	/r/	/l/	/s/	/ʧ/	/ʃ/	/z/	/ʤ/	/v/	/θ/	/ð/	/ʒ/	Other
	6	10	13	17	15	16	13	11	8	19	18	8	3
10. Number of other speech sound production errors	13												

- To answer Research Question 1, pertaining to the characteristics of speech sound production in children with VI:
  - (1) Questions 1 to 6, demographics and vision and hearing histories;
  - (2) Questions 7 to 10, speech sound production errors;
  - (3) Questions 11 to 13, phonological processes reported;
  - (4) Questions 14 to 17, subsets of the sample with coexisting diagnoses.
- To answer Research Question 2, pertaining to therapy techniques:
  - (5) Questions 18 to 26, children's participation in speech therapy and techniques used.
- To answer Research Question 3, pertaining to whether SSD appeared related to VI, evidence was obtained from Question 14, with Questions 15 to 17 pertaining to the children's coexisting conditions offering additional evidence.

Questions 1 to 6: Demographics and VI Information

Question 1, which asked for the child's initials or pseudo initials, garnered 46 responses, thus establishing the number of children in the sample. Question 2 asked for five responses: (2a) ages (age 4 $n = 2$, age 5 $n = 4$, age 6 $n = 2$, age 7 $n = 5$, age 8 $n = 2$, age 9 $n = 5$, age 10 $n = 3$, age 11 $n = 5$, age 12 $n = 3$, age 13 $n = 2$, age 14 $n = 4$, age 15 $n = 1$, age 17 $n = 2$, age 18 $n = 2$, age 19 $n = 2$, age 20 $n = 1$, age 22 $n = 1$), (2b) gender (26 female, 20 male), (2c) race/ethnicity (five African American, two Native American, 29 Caucasian, six Hispanic/Latino, two Pacific Islander, and one Other), (2d) severity of vision impairment (22 Low Vision, 14 Legally Blind, and 10 Blind), and (2e) whether the vision impairment had been present since birth (41 *yes*, 5 *no*). Question 3 probed hearing status. The 46 responses were 2 mild hearing loss, 3 moderate hearing loss, 1 severe hearing loss, and 40 normal hearing. Question 4, which asked if the child wears hearing aids, yielded six responses, which corresponded to those six children identified with any level of hearing loss in Question 3. Question 5 inquired if the child's need for speech sound production therapy could be related to hearing loss. There were six responses, with 5 *yes* and 1 *unsure*. Question 6 probed if the child uses braille. Of 46 responses, 21 were *yes* and 25 were *no*.

Questions 7 to 10: Speech Sound Production Errors

This set of questions dealt with the number of speech sound production errors each child demonstrated and which speech sounds were in error. Data are reported in Table 1. (Note that Table 1 arranges the phonemes in the developmental order proposed by Sander, 1972, for purposes of developmental analysis, rather than in the place-manner order presented in the survey questions.)

Question 7 asked, for each child, how many speech sounds were produced in error more than 50% of the time. Of the 46 responses, 25 reported that a child had 0 to 4 errors; eight reported 5 to 8 errors; eight reported 9 or more errors; and five reported that a child was nonverbal. Questions 8 and 9 probed which phonemes were in error more than 50% of the time and were produced inappropriately for chronological age. There were 46 responses to both questions across the 24 phonemes listed. Reported as being in error were /p/ $n = 9$, /m/ $n = 6$, /h/ $n = 5$, /n/ $n = 6$, /w/ $n = 4$, /b/ $n = 6$, /k/ $n = 8$, /g/ $n = 9$, /d/ $n = 3$, /t/ $n = 6$, /ŋ/ $n = 8$, /f/ $n = 11$, /j/ $n = 6$, /r/ $n = 10$, /l/ $n = 13$, /s/ $n = 17$, /ʧ/ $n = 15$, /ʃ/ $n = 16$, /z/ $n = 13$, /ʤ/ $n = 11$, /v/ $n = 8$, /θ/ $n = 19$, /ð/ $n = 18$ times, /ʒ/ $n = 8$, "other" $n = 3$.

To analyze the results of Questions 8 and 9, the responses were considered for two age groups: children ages 4 through 8 and children ages 9 and older. This age demarcation is based on Sander's (1972) data that typically children master English speech sounds by 8 years of age. Of the 46 responses, 31 responses indicated errors that children age 9 or older produced. For all children, the later developing sounds (/r/, /l/, /s/, /ʧ/, /ʃ/, /z/, /ʤ/, /v/, /θ/, /ð/, /ʒ/) were more likely to be produced in error. Some children ages 9 and older produced errors on all speech sounds.

Of the 46 responses to Questions 8 and 9, except for one phoneme, /w/, there was more representation by children

with low vision than the other levels of severity of VI, probably due to the greater representation of children with low vision in the sample.

Question 10 asked about speech sound production errors. Thirteen open-ended responses mentioned cluster reduction, consonant deletion, and misarticulation of phonemes of each manner and in all positions in words.

The data revealed by Questions 7 to 10 are represented in Table 2. All 24 phonemes were reported to be in error for at least one child within the sample. All children had some speech sound production errors. Table 2 indicates the children's severity of VI and whether the VI was present since birth. (The column "Subset of the sample" indicates the coexisting conditions that were identified by Questions 14-17.)

Questions 11 to 13: Phonological Processes

Question 11 asked if speech sound errors were motoric or phonological. The 46 responses included 25 reports of distortions, 8 reports of a combination of articulation and phonological processes, 6 reports of apraxia, 6 reports of dysarthria, and 1 report of phonological processes. Questions 12 asked which phonological processes occurred most often. Question 12 tallied 3 fronting, 1 backing, 2 stopping, 2 devoicing, 2 voicing, 9 cluster reduction, 3 final consonant deletion, 6 gliding, 3 "other," and 14 that the child exhibited no phonological processes. The responses for Questions 11 and 12 were inconsistent. For Question 11, a total of 9 responses affirmed the presence of phonological processes. In Question 12, 28 instances were reported, along with 3 "other" responses (31 total responses). Question 13, which asked if other phonological processes were evident, yielded 1 report of nasalization, 1 report of syllable deletion, and 1 report of interdentalization. Accurate accounting of phonological processes was not obtained, given the inconsistent and overlapping responses.

Questions 14 to 17: Relating Speech Sound Productions to Other Diagnoses

Questions 14 through 17 asked respondents to relate each child's speech sound productions to the child's other diagnoses. Data are provided in Table 3.

Question 14 asked whether each child's speech sound productions problem was related to the child's VI. There were four response options: that the speech sound production problem was related to a vision problem (e.g., both have the same origin), with 5 responses; that the speech sound production problem was probably related to a vision problem, with 4 responses; that the speech sound production problem was not related to a vision problem, with 31 responses. Six responses indicated that the relation was unknown.

Question 15 asked for the SLPs' opinions about the children's speech sound production skills. Four responses indicated the children's speech sound productions were expected for age level; 14 stated the speech sound productions were expected given the child's primary diagnostic condition; 24 stated speech sound productions were unexpected for age level; 1 stated speech sound productions were unexpected, given the child's primary diagnostic condition; and 3 where the SLP did not know.

Question 16 asked for each child's coexisting diagnoses, with 16 options from which to choose. There were 5 reports of a mild language disorder; 11 moderate language disorder; 7 severe language disorder; 4 mild cognitive impairment; 12 moderate cognitive impairment; 4 severe cognitive impairment; 9 genetic disorder; 20 cerebral palsy, prematurity, low birth weight, and other birth-related issues; 3 illness of the brain; 1 brain injury; 3 autism; 8 injury or disease of the eye or visual mechanism; 1 metabolic or growth disorder; 1 report of not sure; 4 reports of no other diagnoses. Eleven open-ended responses were obtained, all of which could have been placed within the forced-choice options and would have added to the number with brain injury and genetic conditions.

Question 17 asked for other diagnoses, or if more information was needed to explain the responses that were given. Twelve open-ended responses were obtained, all of which could be subsumed under the options in Question 16 and would have increased the number with brain injury, prematurity, and eye disorders.

Subsets of the sample. It was evident from the diagnoses reported in Questions 14 to 17 that VI co-occurred in the setting of many other impairments or conditions that are known to affect speech sound productions. It was necessary to collapse these various diagnoses into manageable subsets of impairments. Assigning a child to just one subset was determined by considering the diagnostic importance of the impairment. The most complicating or disabling condition was used to assign each child because, potentially, it would have the greatest detrimental effect on speech sound production. For example, if a child was identified as being nonverbal, but also had a motor speech disorder, he or she was placed in the nonverbal subset based on the reasoning that being nonverbal is more disabling.

Seven subsets emerged based on their diagnostic commonalities:

- No other diagnoses ($n = 3$);
- Nonverbal ($n = 5$);
- Dual sensory impairments ($n = 4$);
- Motor speech disorders ($n = 7$);
- Mild language disorder ($n = 4$);
- Complex conditions, ages 4 through 8 ($n = 8$);
- Complex conditions, ages 9 and older ($n = 15$).

Table 2. Speech Sound Errors and Characteristics of the Sample.

Age	Gender	Speech sounds in error	Severity of VI	VI present since birth	Subset of the sample
4	Female	/f/, /r/, /l/, /v/ /θ/, /ð/	Low vision	Yes	Complex conditions, birth through age 8
4	Male	No specific sounds reported	Legally blind	Yes	Dual sensory impaired (hearing and vision)
5	Male	No specific sounds reported	Legally blind	Yes	Nonverbal
5	Male	/p/, /g/, /j/, /s/, /ʧ/, /ʃ/, /ʤ/	Legally blind	Yes	Complex conditions, birth through age 8
5	Female	No specific sounds reported	Low vision	Yes	Nonverbal
5	Female	No specific sounds reported	Legally blind	No	Complex conditions, birth through age 8
6	Female	No specific sounds reported	Legally blind	Yes	Complex conditions, birth through age 8
6	Female	/p/, /m/, /h/, /n/, /w/, /b/, /k/, /g/, /d/, /ʧ/, /ŋ/, /f/, /j/, /r/, /l/, /s/, /ʧ/ /ʃ/, /z/, /ʤ/, /v/, /θ/, /ð/, /ʒ/	Blind	Yes	Complex conditions, birth through age 8
7	Male	/ŋ/, /j/, /s/, /ʃ/, /θ/, /ð/	Low vision	Yes	Complex conditions, birth through age 8
7	Male	/p/, /m/, /h/, /n/, /b/, /k/, /g/, /d/, /ʧ/, /ŋ/, /f/, /j/, /r/, /l/, /s/, /ʧ/, /ʃ/ /z/, /ʤ/, /v/, /θ/, /ð/, /ʒ/	Low vision	Yes	Motor speech disorder (apraxia)
7	Female	No specific sounds reported	Low vision	Yes	Nonverbal
7	Male	/f/, /s/, /ʃ/, /θ/, /ð/	Legally blind	No	Mild language disorder
7	Male	/p/, /m/ /b/, /f/, /v/	Blind	Yes	Complex conditions, birth through age 8
8	Female	/s/, /ʃ/, /z/	Blind	Yes	Complex conditions, birth through age 8
8	Male	/ʧ/, /ʃ/	Low vision	Yes	No other diagnoses
9	Male	/n/, /k/, /g/, /ŋ/, /f/, /ʧ/, /ʃ /, /ʤ/, /θ/, /ð/	Low vision	Yes	Dual sensory impaired (hearing and vision)
9	Male	/r/, /l/	Low vision	Yes	Complex conditions, age 9 and above
9	Female	No specific sounds reported	Low vision	Yes	Nonverbal
9	Male	/h/, /n/, /w/, /k/, /g/, /ʧ/, /ŋ/, /f/, /j/, /r/, /l/, /s/, /ʧ/, /ʃ/, /z/, /ʤ/ /v/, /ʒ/	Low vision	Yes	Complex conditions, age 9 and above
9	Female	/s/, /ʧ/, /ʃ/, /z/	Low vision	Yes	Mild language disorder
10	Male	/s/, /z/, /θ/	Legally blind	Yes	Complex conditions, age 9 and above
10	Female	/p/, /b/, /k/, /g/, /ŋ/, /f/, /s/, /ʧ/, /z/, /ʤ/, /θ/, /ð/, /ʒ/	Low vision	No	Dual sensory impaired (hearing and vision)
10	Female	/w/, /ŋ/, /ʧ/, /ʃ/, /ʤ/, /ʒ/	Low vision	Yes	Complex conditions, age 9 and above
11	Male	No specific sounds reported	Legally blind	Yes	Nonverbal
11	Male	/m/, /n/, /k/, /g/, /ʧ/, /r/, /l/, /ʧ/, /ʃ/, /z/, /ʤ/, /θ/, /ð/, /ʒ/	Blind	Yes	Motor speech disorder (dysarthria)
11	Male	/l/	Blind	Yes	Complex conditions, age 9 and above
11	Female	/l/, /θ/, /ð/	Legally blind	Yes	Complex conditions, age 9 and above
11	Male	/s/, /z/, /θ/, /ð/	Blind	Yes	Mild language disorder
12	Female	No specific sounds reported	Low vision	Yes	Complex conditions, age 9 and above
12	Female	/s/	Low vision	Yes	No other diagnoses
12	Female	/p/, /m/, /b/, /l/, /θ/, /ð/	Blind	No	Complex conditions, age 9 and above
13	Female	No specific sounds reported	Low vision	Yes	Complex conditions, age 9 and above
13	Female	/s/, /z/, /θ/, /ð/	Blind	Yes	Dual sensory impaired (hearing and vision)
14	Female	/s/, / ʧ /, /ʃ/, /z/	Low vision	Yes	Complex conditions, age 9 and above
14	Female	/θ/, /ð/	Legally blind	Yes	Complex conditions, age 9 and above
14	Male	/r/, /l/, / ʧ/, /ʃ/, /ʤ/	Low vision	Yes	Mild language disorder
14	Male	/s/	Low vision	Yes	No other diagnoses
15	Female	/ʧ/, /ʃ/, /ʤ/, /ʒ/	Low vision	No	Motor speech disorder (dysarthria)
17	Female	/p/, /m/, /h/, /n/, /w/, /b/, /k/, /g/, /d/, /ʧ/, /ŋ/, /f/, /j/, /r/, /l/, /s/, /ʧ/ /ʃ/, /z/, /ʤ/, /v/, /θ/, /ð/, /ʒ/	Legally blind	Yes	Motor speech disorder (dysarthria)
17	Female	/k/, /g/, /r/, /l/, /s/, /z/, /θ/, /ð/	Blind	Yes	Motor speech disorder (apraxia)
18	Male	/r/, /l/, /θ/, /ð/	Legally blind	Yes	Motor speech disorder (dysarthria)
18	Female	No specific sounds reported	Low vision	Yes	Complex conditions, age 9 and above
19	Female	/p/, /f/, /ʧ/, /v/	Low vision	Yes	Motor speech disorders (apraxia)
19	Female	/θ/, /ð/	Legally blind	Yes	Complex conditions, age 9 and above
20	Female	/p/, /h//ʧ/, /f/, /v/	Low vision	Yes	Complex conditions, age 9 and above
22	Male	/θ/, /ð/	Blind	Yes	Complex conditions, age 9 and above

Table 3. Relating Speech Sound Productions to Coexisting Diagnoses.

Survey question	Number of responses				
14. The student's speech sound production problem:	Is related to a vision problem = 5	Is probably related to a vision problem = 4	Is probably not related to a vision problem = 31	Do not know = 6	
15. The student's speech sound production skill is:	Expected for age level = 4	Expected given primary diagnosis = 14	Unexpected for age level = 24	Unexpected given primary diagnosis = 1	Do not know = 3
16. Other diagnoses	Mild language delay/ disorder = 5	Moderate language delay/disorder = 11	Severe language delay/ disorder = 7	Mild cognitive impairment = 4	Moderate cognitive impairment = 12
	Severe cognitive impairment = 4	Brain injury = 1	Encephalitis, meningitis, other illness of the brain = 3	A genetic disorder = 9	Cerebral palsy, prematurity, low birth weight, other birth-related issues = 20
	Metabolic or growth/ development disorder = 1	Autism = 3	Injury to or disease of the eye or visual mechanism = 8	No other diagnoses = 4	Not sure = 1
	Other = 11				
17. Explanations and comments	12				

Three children ages 9 and older had no other diagnoses, representing 6% of the sample. They had in common several traits: normal hearing, low vision, using braille, no phonological disorder, and speech sound production irregularities were probably not related to a vision problem. Their errors were distortion of /s/ for two children and distortions of /ʧ/ and /ʃ/ for a third child.

Five children, representing 11% of the sample, were nonverbal. These children had multiple coexisting conditions, including severe language disorder, severe cognitive impairment, cerebral palsy, prematurity, injury to or disease of the eye or visual mechanism, metabolic or growth disorder, epilepsy, and/or genetic disorder.

Six children had dual sensory impairments of vision and hearing. Two who were nonverbal were excluded from this subset and are reported within the nonverbal subset. Four children with dual sensory impairment, ages 9 and older, represented 9% of the sample. Two children with severe or moderate hearing impairment had, respectively, nine and 15 speech phonemes in error, while two children with mild hearing impairment had, respectively, zero and four phonemes in error. This subset, when compared with the sample, produced a smaller array of sounds in error. Nine phonemes were not produced in error.

Twelve children had motor speech disorders. Five were accounted for in the nonverbal subset. Seven children, 9% of the sample, had a range of comorbid conditions, such as severe language disorder, cerebral palsy, prematurity, moderate cognitive impairment, brain injury, cortical VI, and orthopedic impairment. All 24 phonemes were reported to be in error, with as few as one and as many as five children producing errors on each phoneme.

Four children, 9% of the sample, with mild language disorders ranged in age from 7 to 14 years. The children produced errors on the middle or later developing sounds of /f/, /s/, /ʃ/, /θ/, /ʧ/, /z/, /ð/, /r/, /l/, /ʤ/. This subset produced a smaller array of speech sound production errors than the sample as a whole. One to three children produced errors on 10 phonemes. Fourteen phonemes were produced without error.

The complex conditions subset represented children whose descriptions did not fit within the dual sensory impairment, nonverbal, motor speech disorders, and mild language impairment subsets based on the presence of other conditions that appeared more disabling. These 23 children constituted 50% of the sample. The complex conditions subset was divided into two groups: children ages 4 through 8 and children ages 9 and older.

Among the eight children with complex conditions ages 4 through 8, 17% of the sample, conditions included albinism, degenerative disease, genetic disorder, optic nerve hypoplasia, Moebius syndrome, and autism. All speech sounds were produced in error among this subset. One to four children in this group produced errors on all 24 phonemes.

Among the 15 children with complex conditions ages 9 and older, 32% of the sample, all phonemes except /d/ were produced in error. Among this subset, at least one and as many as six children produced errors on 23 phonemes. Conditions included mild, moderate, or severe cognitive impairment, cerebral palsy, prematurity, fetal alcohol syndrome, autism, moderate or severe language disorder, in

utero stroke, microcornea, glaucoma, aphakia, severe rod-cone dystrophy, congenital cataracts, and Cohen syndrome.

Questions 18 to 26: Therapy Techniques

Questions 18 to 26 covered the child's history of speech-language therapy. Question 18 asked whether the responder had sufficient information to report on treatment history. There were 46 responses: 28 *yes* and 18 *no*. Those who responded "yes" continued with the remainder of the survey. Improvement could be judged by the SLPs' own work with the child, by report of a prior SLP, or by any other evidence.

Questions 19 and 20 probed for a description of previous speech sounds that were no longer in error. There were 18 responses to both questions across 24 phonemes. Reported were /p/ $n = 3$, /m/ $n = 1$, /h/ $n = 1$, /n/ $n = 1$, /w/ $n = 1$, /b/ $n = 2$, /k/ $n = 3$, /g/ $n = 3$, /d/ $n = 2$; /t/ $n = 0$, /ŋ/ $n = 0$, /f/ $n = 1$, /j/ $n = 0$, /r/ $n = 3$, /l/ $n = 6$, /s/ $n = 5$, /ʧ/ $n = 2$, /ʃ/ $n = 3$, /z/ $n = 2$, /ʤ/ $n = 2$, /v/ $n = 0$, /θ/ $n = 4$, /ð/ $n = 5$, /ʒ/ $n = 0$, "other" $n = 3$. Across the 18 responses, for each phoneme, six or fewer of the children had mastered the phoneme.

Question 21 inquired about previous phonological processes that were no longer in error. There were 18 responses: 1 fronting, 1 backing, 3 devoicing, 1 cluster reduction, 8 that no phonological processes were previously in error. "Other" responses cited 2 gliding and 1 fronting.

Question 22 asked about effective therapy techniques. Fourteen of 19 responses were relevant to the question. Techniques can be summarized as auditory (discrimination tasks using audio recording, amplified auditory feedback, verbal description of target placement), visual (demonstration, enlarged print), tactile (3-D models of the mouth, touch cues, tactile objects to represent sounds), and motoric (drill work of articulatory placement in isolation, then in words, then in phrases; teaching compensatory strategies, for example, due to decreased lip movement, strengthening muscles through bubble blowing, horns, straw drinking; repeating a model with a slower rate).

Question 23 probed therapy progress. Of 28 responses, 15 reported adequate yearly progress in speech improvement, given their age and other conditions; 8 reported some yearly progress in speech improvement, given age and other conditions; and 5 reported children were not making yearly progress in speech improvement, given age and other conditions.

Question 24 asked about improvement of phonological processes. The following processes were noted as improved: 1 report each for fronting, backing, stopping, devoicing, and voicing; 2 reports each for backing and cluster reduction; 3 final consonant deletion; 8 reports of no phonological process; and 8 responses of "other," such as gliding.

Question 25 asked to describe the most effective speech sound intervention techniques. The 14 responses were similar to the responses to Question 22. Traditional articulation therapy included activities, games, iPads, and speech-generating devices.

Question 26 asked for the total amount of time that the SLPs had provided speech sound production therapy for the child. Of 28 responses, 6 responded the time spent providing treatment was less than 1 school year (less than 9 months); 3 responded that treatment lasted for 1 full school year; 4 reported treatment for more than 1 school year, but less than 2; 5 indicated treatment for more than 2 full school years, but less than 3; 5 indicated treatment for 3 full school years; and 5 indicated treatment for 4 or more school years.

Discussion

Research Question 1 identified the speech sound production characteristics of children with VI. The exact characteristics, attributes, or patterns of speech sound production errors for this sample of children with VI could not be identified due to the children's multiplicity of coexisting medical and developmental conditions, which resulted in a diverse sample. These conditions possibly contributed to children's speech sound productions in various ways.

A consistent finding was the numerous reports of speech sound production errors well after the age of 8. This sample showed a higher occurrence of error productions than might be predicted by the norms (Sander, 1972). In the general population, a child's advancing age has a strong relationship with the improvement of speech sound accuracy. In this sample, age seemed to have no relationship to the accuracy of the children's speech sound productions. There was no phoneme that every child in the sample had mastered, meaning that every phoneme was reported to be in error for at least one child. All 24 phonemes were reported as being in error for at least one child in the ages 9 and older group. No child ages 9 or older mastered all 24 consonantal phonemes. The occurrence of SSD far exceed the prevalence figure of 8% to 9% in the general population (NIDCD, 2010).

In Table 4, the number of errors for each speech sound was ranked by frequency of report, from least to most often reported. Table 4 shows that the median number of errors per phoneme was 8. Modes for this distribution were 6 and 8.

This ranking revealed that certain phonemes were more frequently produced in error. The phonemes reported at the median frequency or more were /k/, /ŋ/, /v/, /ʒ/, /p/, /g/, /r/, /f/, /ʤ/, /l/, /z/, /ʧ/, /ʃ/, /s/, /ð/, and /θ/. The phonemes reported most were /ð/ and /θ/.

With 67% of children in the sample being age 9 and older ($n = 31$; with 15 children being ages 4-8), it is notable that of the phonemes that occurred at the median frequency or greater, /p/, /g/, /k/, and /f/ are earlier developing (Sander, 1972). Twenty-four of the 46 responses indicated that errors were unexpected for age (Question 15). However,

Table 4. Frequency of Reported Speech Sound Production Errors.

Speech sound	Frequency of reported production errors	
/d/	3	
"other"	3	
/w/	4	
/h/	5	
/m/	6	
/n/	6	
/b/	6	
/t/	6	
/j/	6	
/k/	8	
/ŋ/	8	
/v/	8	
/ʒ/	8	Median
/p/	9	
/g/	9	
/r/	10	
/f/	11	
/dʒ/	11	
/l/	13	
/z/	13	
/ʧ/	15	
/ʃ/	16	
/s/	17	
/ð/	18	
/θ/	19	

coexisting conditions were likely to have contributed to the children's speech sound productions. Fourteen responses indicated that the errors were expected, given the presence of these conditions (Question 15). While some phonological processes were reported, these reports were not as frequent or as consistent as the reports of articulation and motor speech disorders.

Some speech sound patterns within the sample did emerge. It is notable that the two phonemes most frequently reported as in error were the linguodental fricatives /θ/ and /ð/, at 19 and 18 times, respectively. When combined with Questions 19 and 20 regarding previous speech therapy, the number of reports rose to 23 for both /θ/ and /ð/, meaning that 50% of the sample had at one time received therapy or was currently misarticulating /θ/ and /ð/ (consistent with data on frequent errors on /θ/ and /ð/ obtained by Brouwer et al., 2015). These two sounds were the sole phonemes in treatment for the oldest male, age 22, and oldest female, age 19, in the sample. The articulatory placement for these phonemes is visible when spoken, and their manner and voicing may be subtle and not easily discernable based on their auditory characteristics.

Another pattern of persistent speech sound production errors was noted for the phonemes /k/, /p/, /g/, and /f/. For phonemes /k/ and /g/, adolescents as old as 17 were receiving remediation. For phonemes /p/ and /f/, young adults up to the age of 20 were receiving remediation.

Fifty-four percent of the sample, 25 of the 46 children, had articulation errors typified by speech sound distortions. The remaining 25 children had motor speech disorders or a combination of articulation errors and phonological processes. With a majority of the sample exhibiting articulation distortions, it can be concluded that these children with VI demonstrated imprecise articulation. Mills (1987) also reported imprecise articulation among a sample of children with VI.

In discussing the treatment methods that the SLPs reported as useful for children with VI, it is necessary to recall effective treatment approaches for all children. Williams (2003) described the three components of treatment efficacy as "the three Es": efficiency, effects, and effectiveness. Efficiency can be determined by how long it takes a child to achieve goals and how much effort it took to effect change. Effects refer to whether the changes that occurred were significant. Effectiveness refers to whether the changes that occurred can be attributed to therapy.

Regarding effects and effectiveness, several speech sound interventions brought about success. Based on the 28 responses received for Questions 22 and 25, the SLPs used traditional articulation therapy augmented to accommodate for VI, such as generous amounts of modeling, repetition, tactile cuing, and verbal description of articulatory placement. It became clear that none of the SLPs reported knowledge or use of techniques that specifically target interventions for individuals with VI. This echoes the report by Brouwer et al. (2013), in which SLPs reported no specific speech therapy techniques for working with children with VI.

Responses to Question 2 helped determine whether the SLPs' treatments were efficient, as meaning accomplished in a reasonable period. Of the 28 SLPs who commented on a child's yearly progress, 15, or 54%, claimed that a child had made adequate yearly progress. This information contrasted with the fact that developmental speech sound production delays persisted for 54% of the sample, who had speech sound production errors that were inappropriate for their ages. This leads to speculation about whether children with VI might need speech sound production therapy for a greater number of years than sighted children who are addressing the same sounds. However, the presence of coexisting medical and developmental conditions in the children in this sample potentially contributed to the year-to-year continuation of speech therapy.

Research Question 3 inquired whether the SLPs perceived that a lack of visual input was related to speech sound productions. Of the 46 responses to Question 14, 31 SLPs (67%) stated that the characteristics of the children's speech sound productions were probably not related to the vision problem. In response to Question 15, 14 responses (30%) stated that the speech sound production

skills were expected given coexisting conditions. The SLPs attributed speech sound production errors to developmental delays and coexisting diagnoses rather than to the presence of VI.

Implications

This study contributed to the available information about speech sound productions in children with VI, particularly when coexisting conditions are present. Findings may give SLPs an indication of the speech sound production errors that might occur in students with complex communication needs and with low incidence disorders. The information on the persistence of SSD and the variability in therapy progress over time could offer SLPs practical comparative information.

This study offered evidence pertaining to successful practices by SLPs who serviced children with VI. The SLPs adapted their existing knowledge of articulation therapy strategies to provide the best possible interventions to children with VI (cf. Brouwer et al., 2013).

Limitations

Although this study provided a great deal of information about this sample of children with VI, there were some limitations to the study. A main limitation was the sample size. With only 46 children from which to glean data, a generalization to the overall population of children with VI cannot be made. The sample was composed largely of students who attended state schools for students with VI and who were thus likely to be students with greater needs than students who attend community schools. Another limitation comes from the design of the survey. The questions regarding effective treatment methods were in an "optional" response section. A required response could have generated more data on the treatment techniques.

Future Research

SLPs would benefit from additional knowledge and training pertaining to quality interventions for children with VI, as House and Davidson (2000) and Brouwer et al. (2013) reported. Although the present data provided some useful information about the characteristics of speech sound productions among children with VI, future research should focus on gathering information on children with VI as their only medical or developmental condition, excluding children with multiple impairments and coexisting diagnoses. To gain a clearer understanding of what types of speech sound errors are prevalent in children with VI, a more homogeneous sample will need to be obtained.

Appendix

Speech Sound Development in Children With Vision Impairments

THIS SURVEY REQUIRES YOU TO PROVIDE CLINICAL INFORMATION ABOUT THE CHILDREN/TEENS WITH VISION IMPAIRMENTS FOR WHOM YOU HAVE PROVIDED SPEECH SOUND PRODUCTION THERAPY (TREATMENT OF PHONOLOGY, ARTICULATION, APRAXIA, DYSARTHRIA).

YOU MAY INCLUDE CHILDREN/TEENS WITH VISION IMPAIRMENTS FOR WHOM YOU HAVE PROVIDED SPEECH SOUND PRODUCTION THERAPY AND OTHER INTERVENTIONS (LANGUAGE, FLUENCY, VOICE, AAC, SOCIAL, COGNITIVE, HEARING, OTHER).

DO NOT REPORT ON CHILDREN/TEENS WITH VISION IMPAIRMENTS FOR WHOM YOU HAVE PROVIDED INTERVENTIONS THAT DID NOT INCLUDE SPEECH SOUND PRODUCTION THERAPY.

The questions that follow are designed to be answered as a report of one student with a vision impairment. When you finish the questions, you may choose to begin the set of questions again and report on another student, or you may end your participation. You may respond to this questionnaire as many times as you choose to characterize as many individual children/teens with a vision impairment as you care to describe, up to a maximum of 50 children/teens.

Remember, the inclusionary criteria are:

The child/teen is age birth to 21.

The child/teen has a vision impairment as defined by this survey.

You provided the child/teen with interventions for speech sound production.

For each question, please select the best option given. Each question has a comment box that allows you to offer a response that is not listed or where you can add any additional information.

Here is a review of the severity levels of vision impairment:

Description of Severity of Visual Impairments with Corrective Lenses:

1. Low vision (20/60 to 20/200): A moderate visual impairment, not necessarily limited to distance vision. Includes difficulty reading at a normal viewing distance and seeing details.
2. Legally Blind or Severe Low Vision (20/200 to 20/500): Gross orientation and mobility are generally adequate, but difficulty seeing traffic signs, bus numbers, etc. Reading requires high power magnifiers and/or very short reading distances.
3. Blind (20/500 to No Light Perception): Problems with visual orientation and mobility. Vision is unreliable

except under ideal circumstances, or possibly no light perception.

4. Functions at the Definition of Blindness (FDB): Visual functioning is reduced by a brain injury or dysfunction. Visual acuity is not possible to determine using the Snellen Chart.

1) Student's initials (use real or pseudo initials; however, make sure that you do not use the same initials for another child):_____
_____

2) Student
Age: _____
Gender: _____
Race/Ethnicity: _____
Severity of vision (See description above):
Vision impairment present since birth:

3) Hearing Status:
___ No apparent hearing impairment
___ Mild hearing loss
___ Moderate hearing loss
___ Severe hearing loss
___ I am not sure

4) Does this student wear hearing aids?
___ Yes
___ No
___ Unsure

5) Can this student's needs for speech sound production therapy be related to having a hearing loss?
___ Yes
___ No
___ Unsure

6) Is the student learning braille (or has learned)?
___ Yes
___ No
___ Unsure

7) Speech contains:
___ 0-4 speech sounds in error more than 50% of the time
___ 5-8 speech sounds in error more than 50% of the time
___ 9+ speech sounds in error more than 50% of the time
___ I am not sure
___ The child is generally non-verbal

Reference list:
/b/ (boy); /p/ (pan); /g/ (game); /k/ (cat, kite); /d/ (dog); /t/ (tiger); /tʃ/ (child); /dʒ/ (jump); /r/ (run); /l/ (light); /z/ (zoo); /s/ (sun); /ʃ/ (shoe); /ʒ/ (measure); /θ/ (think); /ð/ (the); /f/ (fast); /v/ (vehicle); /h/ (height); /m/ (man); /n/ (nine); /ŋ/ (ring); /w/ (water); /j/ (yellow)

8) Which of the following does the child misarticulate greater than 50% of the time in any position in words and is inappropriate for chronological age?

__ /b/ ___/p/ __ /g/ __ /k/ ___/d/ ___/t/ __ /tʃ/ __ /dʒ/ __ /r/ __ /l/ __ /z/ __ /s/

9) Continued from question 8: Which of the following does the child misarticulate greater than 50% of the time in any position in words and is inappropriate for chronological age?

__ /ʃ/ __ /ʒ/ __ /θ/ __ /ð/ __ /f/ __ /v/ __ /h/ __ /m/ __ /n/ __ /ŋ/ __ /w/ __ /j/ __ Other

10) If other speech sound production errors are occurring, please describe below.
_____
_____
_____
_____

11) Speech sound errors are primarily:
___ Distortions (articulation)
___ Phonological processes
___ Combination of both articulation and phonological processes
___ Apraxia
___ Dysarthria

12) If phonological processes are evident, which are most occurring?
___ Fronting (gate -> date)
___ Backing (bat -> gat)
___ Stopping (sun -> tun)
___ Devoicing (dad -> tat)
___ Voicing (kite -> gide)
___ Cluster reduction (black -> back)
___ Final consonant deletion (dog -> do)
___ Gliding (red -> wed)
___ No phonological processes
___ Other

13) If other phonological processes are occurring, please describe below.

_____

_____

_____

_____

14) The student's speech sound production problem:

___ Is related to a vision problem (both have the same origin, such as cerebral palsy)
___ Is probably related to a vision problem
___ Is probably not related to a vision problem
___ I do not know whether this child's speech problem is related to a vision problem

15) The student's speech sound production skill is:

___ Expected for age level
___ Expected given the child's primary diagnostic conditions (e.g., cerebral palsy)
___ Unexpected for age level
___ Unexpected for the child's primary diagnostic conditions (e.g., cerebral palsy)
___ I do not know the relationship between the child's primary diagnostic conditions and the speech sound production problem

16) This student has been diagnosed with:

___ Mild language delay/disorder
___ Moderate language delay/disorder
___ Severe language delay/disorder
___ Mild cognitive impairment
___ Moderate cognitive impairment
___ Severe cognitive impairment
___ A genetic disorder (any syndrome, sequence)
___ Cerebral palsy, prematurity, low birth weight, other birth related issues
___ Encephalitis, meningitis, other illness of the brain
___ Brain injury after the age of 2
___ Autism
___ Injury to or disease of the eye or visual mechanism
___ Metabolic or growth/development disorder
___ I am not sure
___ No other diagnoses
___ Other (Please specify)

17) If the student has other primary diagnosis (e.g., Down Syndrome, Fragile X) or if you would like to provide other relevant information to explain your responses for this student, use the space below. (Optional)

_____

_____

_____

_____

Optional section questions 18-26:

It would be very helpful to know more about the student's speech history. Please report on previous speech therapy and development for the following questions if possible.

18) I have sufficient history with this student and would like to report about previous therapy.

___ Yes
___ No

19) Which of the following FORMER speech sound goals are no longer in error?

__ /b/ ___/p/ __ /g/ __ /k/ ___/d/ ___/t/ __ /tʃ/ __ /dʒ/ __ /r/ __ /l/ __ /z/ __ /s/

20) Continued question 19:

__ /ʃ/ __ /ʒ/ __ /θ/ __ /ð/ __ /f/ __ /v/ __ /h/ __ /m/ __ /n/ __ /ŋ/ __ /w/ __ /j/
__ Other (Please specify)

21) Which of the following phonological processes are no longer in error?

___ Fronting (gate -> date)
___ Backing (bat -> gat)
___ Stopping (sun -> tun)
___ Devoicing (dad -> tat)
___ Voicing (kite -> gide)
___ Cluster reduction (black -> back)
___ Final consonant deletion (dog -> do)
___ Gliding (red -> wed)
___ No phonological processes
___ Other (Please specify)

_____

22. In my work with this student, the most effective speech intervention techniques have been (skip if you do not have familiarity or do not have success to report):

_____

_____

_____

_____

23. Progress:

___ This student has made adequate yearly progress in speech improvement, given age and other conditions.

___ This student makes some yearly progress in speech improvement, given age and other conditions.
___ This student does not make yearly progress in speech improvement, given age and other conditions.
___ I do not know whether this student makes yearly progress in speech improvement.

24. Please mark all areas where you have evidence of improvement (your work with the child, prior SLP's work, other evidence):

___ Fronting (gate -> date)
___ Backing (bat -> gat)
___ Stopping (sun -> tun)
___ Devoicing (dad -> tat)
___ Voicing (kite -> gide)
___ Cluster reduction (black -> back)
___ Final consonant deletion (dog -> do)
___ Gliding (red -> wed)
___ No phonological processes
___ Other (Please specify)
_____

25) Please describe the most effective speech sound intervention techniques that you used with this student.

_____
_____
_____
_____
_____
_____
_____
_____

26. The total amount of time that you provided speech sound production therapy for this student was:

___ Less than one school year - under 9 months
___ One full school year
___ More than one full school year, but less than two
___ Two full school years
___ More than two full school years, but less than three
___ Three full school years
___ More than three full school years, but less than four
___ Four or more school years

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