Proposed Missouri DESE Developmental Standards for Sound System Disorder: Research Base

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There is much evidence for the importance of articulation therapy in preschool and school-age populations. In a survey of 784 school-based speech-language pathologists, nearly all clinicians (92%) reported they served individuals with articulation or phonological disorders, and sound system disorders made up the largest part of pediatric speech-language pathology caseloads (ASHA, 2003). Also, sound system disorder (SSD) has been shown to affect children in many areas besides speech, including language and social development (Catts, 1993; Larrivee & Catts, 1999; Raitano et al., 2004; Rvachew et al., 2003; Bird, Bishop, & Freeman, 1995; Webster, Plante, & Couvillion, 1997).

Effective phonology intervention before entry to school has been found to be an important priority (Shriberg & Kwiatkowsi,1988; Nathan et al., 2004; Rvachew & Grawburg, 2006; Bird et al., 1995). This calls for greater clinical effectiveness both in the assessment and intervention of SSD. Weisz et al. (1995) found that the greater effectiveness of interventions provided in a research context is in part because of a reliance on specific, focused therapy methods rather than mixed and eclectic approaches. It makes sense that to have specific and focused therapy methods, a clinician would need assessment that is specific and focused. Through a meta-analysis, Law, Garrett, and Nye (2004) concluded that interventions for SSD are effective. When using standardized assessment measures, phonology interventions were favored significantly compared to no treatment, and there was a large significant effect of speech intervention when measured by the percentage of consonants correct in conversation.

For these reasons, it is important for educational systems to have the resources and information they need to identify and treat children with SSD. The purpose of this project is to inform clinical decision making in Missouri public schools by the development of a system for addressing sound system disorder eligibility. The results will inform administrative decision-making by providing criteria for eligibility and updated normative data for making comparisons.

NORMATIVE DATA

Current Guidelines

Criteria to qualify a student for speech services in the area of sound system disorder in Missouri include a delay in correct sound production, the level of sound production is outside normal development using normative data, sound system evaluation including a single word test and a speech sample, errors that compromise overall intelligibility and/or listener perception, adverse educational impact, and dialectal and second language considerations (Missouri State Compliance Plan, 2001). Each school district is free to choose which speech sound acquisition normative data chart is used, although the Missouri Speech-Language-Hearing Association Executive Board endorses a chart based on data from Shriberg (1993). The data in this DESE chart were not developed to be exact "norms" because there is no percent of occurrence figures available (Missouri Speech-Language-Hearing Association, 2007).

Improvements in both sampling methods and specificity were offered when Smit and her colleagues (Smit et al., 1990; Smit, 1993a; Smit, 1993b) published additional reference data regarding the age of sound acquisition, using data collected in Iowa and Nebraska. The data representing the Iowa-Nebraska norms generally showed children reaching 75% acquisition level at ages equal to or younger than ages reported by Templin. Exceptions included /ŋ/ and /r/ which showed 75% acquisition later in the Iowa-Nebraska data (Smit et al., 1990). Other differences were noted regarding the acquisition of clusters. Overall, when a 75% criterion was used, most of the Iowa-Nebraska ages of acquisition were slightly younger than those obtained by Templin. Smit et al. conclude this difference may be due to methodological differences and possible different measures of response adequacy.

There is great variability in preschool phonological acquisition. One difficulty related to sound system eligibility criteria is discerning the difference between a

phonological mismatch that is developmental and will normalize (i.e., correct on its own) and a mismatch that will not normalize without direct intervention. Given this variation, in the current system the categories of eligible, ineligible, and potentially eligible or "questionable" were developed and criteria for each category were set according to the best evidence available. The objective for the potentially eligibile or "questionable" category was to identify additional factors for Individualized Education Plan (IEP) teams to consider in making a decision regarding eligibility.

Overall Level of Phonological Development

Developmental mismatches. There are two sources of data that yield an overall metric of phonological development: standardized tests and the Percent Consonants Correct (Shriberg and Kwiatkowski, 1982). Both of these procedures involve comparison between target forms and the child's productions to determine whether they are matched. The system is binary, with each production being counted as correct or in error. Such systems do not take into account the type of error that occurs. However, error patterns (i.e., omissions) and unusual substitutions are less likely to be associated with typical development and sufficient intelligibility after age 3 (Shriberg, 1993). Consequently, we explored data from Smit, (Smit et al., 1990; Smit, 1993a; Smit, 1993b) were examined and developmental charts displaying mismatches that were potentially developmental at ages 3 years, 4 years, 5 years, 6 years, and 7 years were constructed. Tables with "permitted errors" (i.e., mismatches in production that could feasibly normalize, or correct, over time with continued maturation) per age using data from Sander (1972) were created using this more current research on sound acquisition (Smit et al., 1990; Smit, 1993a; Smit, 1993b). Consideration was given to ages of acquisition at which both 75% and 90% acquisition levels were obtained (see Tables 5-9).

Standardized tests. One of the most frequently used standardized tests of articulation/phonology is *the Goldman-Fristoe Test of Articulation-2 (GFTA-2)*

(Goldman& Fristoe, 2000*)* so it was chosen as the initial test for inclusion in the proposed system. The *GFTA-2* is an articulation test that examines 23 out of 25 sounds generally recognized as Standard English consonants. Consonants and consonant clusters are assessed in the initial, medial, and final positions. The test does not assess vowels and two consonants, which have a low intervention priority compared to other consonants. Although the test is quick and easy to administer, the nature of each error is not considered. That is, all errors are scored the same, regardless of the type of error. A system with single sound substitutions that are developmental could result in the same score as one with deletions and unusual substitutions. Also, when scoring, all targets are treated the same regardless of their age of acquisition or frequency in the language.

Because of this concern regarding test scoring procedures, we explored the charts (Tables 5-9) that contained potentially developmental mismatches (Smit et al., 1990; Smit, 1993a; Smit, 1993b) to determine *GFTA-2* scores that represented the highest number of errors a child could make while still being within developmental limits. Errors considered as developmental for each age (3 years, 4 years, 5 years, 6 years, and 7 years) were used to complete a test protocol for the *GFTA-2*. Protocols were scored based on these developmental errors, and the resulting scores represented the maximum GFTA-2 score a child of each age could have with only developmentally appropriate errors. The corresponding derived scores were used to determine the highest performance score that would be associated with potentially developmental errors. This analysis indicated that a the sound system production of a child with a percentile rank greater than 5 and a standard score of 86 or above could consist entirely of errors that are potentially developmental. Consequently, we recommend that children scoring at these levels should not be considered eligible for SSD services (see Table 1). A *GFTA-2* percenile rank of 5 or below would indicate probability that speech errors are not developmental and will not normalize before early elementary and could be associated with poor literacy

development. Consequently, children falling in this category would be classified at eligible (see Table 2). Scores falling in a questionable range would include a percentile rank greater than 5, but a standard score of 85 or below. These scores would warrant the IEP team's use of specific phoneme and cluster acquisition data, intelligibility levels, and the presences of concomitant poor language skills for eligibility (see Table 3).

The current draft of the normative standards includes suggested levels of interpretation for only the *GFTA-2*. Cut-off scores for eligibility will be developed using other standardized tests when given feedback from DESE regarding other tests that are frequently used in Missouri.

Percent Consonants Correct (PCC). The PCC is the percentage of consonants scored as accurate divided by the total number of consonants produced. Based on data from Shriberg, Austin, Lewis, McSweeny, and Wilson (1997), Gruber (1999) used 85% PCC as a threshold to approximate minimally accurate yet normal, spontaneous, conversational speech production of consonants. Gruber stated many children with speech-delay achieve an 85% PCC criterion, but retain residual distortion errors. While estimating normalization using PCC, Gruber found a 0% probability of normalizing for 85% PCC in conversational speech up to about 54 months of age, which he stated was to be expected given participants were selected based on a manifest speech delay from 37 to 48 months of age. All children achieved the 85% criterion by 83.2 months of age. Shriberg, Austin, Lewis, and McSweeny (1997) reported PCC averages for males and females ages 3-8 who experienced normal speech acquisition and children with speech delay. The average PCC of males and females who experienced normal speech acquisition from a middle developmental sound class was 94.2% with 5.3 being the standard deviation for ages 3:0-3:11, 92.7% with 4.6 being the standard deviation for ages 4:0-4:11, 93.4% with 4.3 being the standard deviation for ages 5:0-5:11, 93.7% with 4.9 being the standard deviation for ages 6:0-6:11, 96.1% with 3.1 standard deviations for

ages 7:0-7:11, 97.2% with 3.2 standard deviations for ages 8:0-8:11. Shriberg and Kwiatkowski (1982) found PCC scores fell into four ranges, including mild from 85-100%, mild-moderate from 65-85%, moderate-severe from 50-65%, and severe being less than 50%. They also found that 27 out of the 30 children's severity ratings were closely estimated by their PCC value alone.

Calculating a child's Percent Consonants Correct (PCC) gives clinicians a quantitative value that can be compared to reference data found on the website for the Phonology Project at the University of Wisconsin (http://www.waisman.wisc.edu/phonology/TREP3_REV.PDF). These data were based on conversational speech samples, but data from Masterson, Bernhardt, and Hofheinz (2005) suggest PCCs based on single word productions elicited by the Computerized Articulation and Phonology Evaluation System (CAPES, Masterson & Bernhardt, 2001) yielded data comparable to conversational speech productions. CAPES elicits word samples partially tailored to participants' phonological profiles, the authors found very few differences in accuracy or treatment ramifications. They noted that the time necessary to elicit and transcribe conversational samples was typically 3 times greater than for single-word samples elicited by CAPES. In summary, we recommend that a sufficient sample be collected and that an overall metric of phonological development be determined. This metric can then be used to make initial decisions regarding eligibility for SSD services.

In summary, we suggest that eligibility decisions for SSD be based on performance on an overall metric. Performance on the metric may indicate (a) ineligibility, (b) eligibility, or (c) questionable eligibility. Performance levels and considerations for each are outlined below.

Speech Production Performance Indicating Ineligibility

If the child's overall metric is higher than the following cut-off levels, there is a reasonable chance that the speech errors are developmental and will normalize over time.

Consequently, the child would be classified as ineligible for services for Sound System Disorder.

Table 1. Performance scores indicating a child would not be eligible for SSD services.

Goldman-Fristoe-2: PR > 5 and a Standard Score of 86 or above

PCC cut-offs:

	Boys	Girls
Age 3	>77.4	>78.6
Age 4	>78.3	>84
Age 5	>88.3	>89.5
Age 6	>90	>89.5

Speech Production Performance Indicating Eligibility

If the child's overall metric is lower than the following cut-off levels, there is a reasonable probability that the speech errors are not developmental, will not normalize by the time the child is in early elementary grades, and may be associated with poor literacy development. Consequently, the child would be classified as ineligible for services for Sound System Disorder.

Table 2. Performance scores indicating a child would be eligible for SSD services.

Goldman-Fristoe-2: Percentile Rank of 5

PCC cut-offs:

	Boys	Girls
Age 3	<73.5	<70.3
Age 4	<74.8	<76.9
Age 5	<73.4	<76.1
Age 6	<78.8	<86.4

Speech Production Performance Indicating Questionable Eligibility

If the child's score falls between the scores indicating either eligibility or questionable eligibility, the IEP team should determine eligibility by considering specific phoneme and cluster acquisition data, intelligibility levels, and presence of concomitant poor language skills. The range of scores on the overall metric that are associated with questionable eligibility appear below.

Table 3. Performance scores indicating a child may be eligible for SSD services

Goldman-Fristoe-2: PR > 5, but a standard score of 85 or below

PCC cut-offs:

	Boys	Girls
Age 3	73.6-77.4	70.4-78.6
Age 4	74.9-78.3	77-84
Age 5	73.5-88.3	76.1-89.5
Age 6	78.9-90	86.5-89.5

Presence of poor language skills. The potential for SSD to have negative effects on academic outcomes is particularly high for children who also have concomitant language problems (Nathan et al., 2004). Given that the criteria for classifying a preschool child as language-disordered are somewhat stringent in Missouri, the IEP team should consider ruling a child with language scores (MLU, standardized tests, etc.) that fall below 1 standard deviation from the age mean as eligible for SSD if his/her speech data are questionable.

Intelligibility. Intelligibility, the extent to which an individual is understood by others, is important for listener comprehension and is a functional measure of oral communication. Articulation and phonology are necessary for intelligible speech, but many factors can influence whether a person is considered intelligible. Articulation tests generally only address a few of the factors that cause a person to have decreased intelligibility. As Gorden-Brannan and Hodson (2000) stated, "intelligibility data for young children with typical as well as disordered phonologies are generally lacking even though critical clinical decisions often depend on intelligibility" (p. 142), even still, data that do exist are generally comparable. Weiss (1982) reported expected ranges of

intelligibility for young children to by between 26% to 50% by age 2, 51% to 70% by age 2:6, 71% to 80% by age 3, 81% to 90% by age 3:6, and 100% intelligible by age 4, although it has been reported that the procedures for obtaining these data were not made clear (Gordon-Brannan, 1994). Coplan and Gleason (1988) found cutoff ages for 50% intelligibility to be 22 months, 75% intelligibility to be 37 months, and 100% intelligibility to be 47 months after asking parents to rate their children's intelligibility by how much strangers can understand the child. After examining intelligibility in 48 children with normal hearing, Gordon-Brannan and Hodson (2000) suggested that an intelligibility score of less than 66% for a child 4 years or older could be a potential indicator of speech difficulty. The average intelligibility for the group, whose mean age was 4:7, was 85% when the children in the severe intelligibility/speech involvement group were excluded. Based on the percentage of words understood from their continuous speech samples, the children's intelligibility ranged from 91-100% for children with "adult-like" speech, 83-90% for children in the "mild" category, 68-81% for children with moderate intelligibility/speech involvement, and 16-63% for the children in the "severe" category.

The intelligibility of children whose data are in the questionable range should be considered in order to determine eligibility for services for SSD. Although definitive levels of expected intelligibility are somewhat lacking, the levels that are suggested in a variety of studies are somewhat comparable (Coplan & Gleason, 1988, Gordon-Brannon & Hodson, 2000, Weiss, 1982). If a child's intelligibility falls below the expected cut-offs listed below, the IEP team should consider ruling the child eligible for services.

Table 4. Intelligibility cut-offs for each age level

Age	Intelligibility
3:0-3:6	75%
3:6-4:0	80%
4 and beyond	90%

Nature of word structure and segmental errors. A limitation associated with overall metrics is that all mismatches (i.e., "errors") are treated equally. For example, there is no differentiation for deletion, distortion, and substitution errors. However, close examination of developmental data indicate that such mismatches occur with different frequencies in typical development. Consequently, it is important to consider not just the target sound in error, but the nature of the error itself in determining whether the error is likely developmental or not. Studies concerning mismatches associated with typical development (Goldman & Fristoe, 2000, Smit et al., 1990, Smit, 1993b) were examined and the following chart of errors that are potentially developmental and will likely normalize was created. Any error that is not on the chart has a low probability of being typical and normalizing with additional maturation. Consequently, the IEP team should consider ruling a child eligible for services for SSD if his/her speech is characterized by errors not on the chart.

Table 5. Mismatches potentially developmental for age 3

	Acquired	**Potentially Developmental Errors**:
Single Sounds		
Nasals	/m/, /n/	n/ŋ
Stops	/b/ /d/ /p/ /t/ (I) /k/ (F) GFTA-2 sample has /k/ /g/ by 3:6	Deletion of /t/, /p/ (F) (Not in GFTA sample [<85%]) /k/ -> [t] /g/ -> [d] (I,F) /g/ -> [k] (F) *Fronting Velars, Devoicing Final Consonants*
Glides	/w/	Deletion of /j/ /j/ -> [w]
Fricatives	/f/ /h/	/v/ -> [b] or [f] ((I) /v/ -> [b] or [f] or deleted (F) /θ/ -> [f], [s], [t], [d] (I) /θ/ -> [f], [s] (F) /ð/ -> [d] /s/ -> [t], dentalized (I) /s/ -> [t], dentalized, deleted (F) /z/ -> [d], [ts], [s], [dʒ], dentalized (I) /z/ -> [d], [ts], [s], dentalized, deleted (F) /ʃ/ -> [s], [t], [d] (I) /ʃ/ -> [s], [t], dentalized, deleted (F) *Stopping Fricatives* *Fronting Palatals* *Devoicing Final Consonants* *Dental Distortion of Sibilants*
Affricates		/tʃ -> [t], [d], [ʃ], [ts] /dʒ/ -> [d] (I) /dʒ/ -> [dz], [tʃ] (F) *Stopping Affricates* *Fronting Palatals*
Liquids		/l/ -> [w] (I) /l/ -> [w], [d] (intervocalic) /l/ -> vocalized, deleted (F) /r/ -> [w], derhotasized (distorted) (I) /r/ -> vocalized, deleted (F) *Gliding Liquids* *Derhoticized (Distortion) of /r/* *Vocalization of Liquids* *Deletion of Liquids*
Clusters		
Stop+/w/	/tw/, /kw/ (Age 3:6)	Some reduced to stop
Consonant + Liquid		Liquid deleted or replaced by [w] or derhoticized (/sl/ usually reduced to [s]; however, may be reduced to [l]) (Note: Remaining consonant may be affected by substitution affecting single sounds at this age)
/s/ + Consonant		/s/ deleted (/sl/ usually reduced to [s]; however, may be reduced to [l]) (Note: Remaining consonant may be affected by substitution affecting single sounds at this age)
/s/+Consonant + Consonant		kw/ typically reduced to [k], which may also be affected by the same substitution that affects singletons pr/ and /spl/ typically reduced to [p]

Table 6. Mismatches potentially developmental for age 4

	Acquired	**Potentially Developmental Errors**
Single Sounds		
	Acquired	Potentially Developmental Errors
Nasals	/m/, /n/ /ŋ/	
Stops	/b/ /d/ /p/ /t/ /k/ /g/	
Glides	/w/ /j/	
Fricatives	/f/ /h/	/v/ -> [b] ((I) /v/ -> [b] or [f] or deleted (F) /θ/ -> [f], [s], [t], [d] (I) /θ/ -> [f], [s] (F) /ð/ -> [d] (I, F) /s/ -> dentalized /z/ -> [d], [ts], [s], dentalized /ʃ/ -> [s] *Fronting Palatals* *Dental Distortion of /s/ and /z/*
Affricates		/tʃ -> [t], [d], [ʃ], [ts] (I, F) /dʒ/ -> [d] (I) /dʒ/ -> [dz], [tʃ] (F) *Stopping Affricates* *Fronting Palatals*
Liquids	GFTA-w has /l/ (I,M) by 4:6	/l/ -> [w] (I) /l/ -> [w], [d] (intervocalic) /l/ -> vocalized (F) /r/ -> [w], derhoticized (distorted) (I) /r/ -> vocalized (F) *Gliding Liquids* *Derhoticized (Distortion) of /r/* *Vocalization of Liquids*
Clusters		
Stop + /w/	/tw/, /kw/	
Consonant + Liquid	C + /l/ (girls 4:6)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/ + Consonant		Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/+Consonant + Consonant		Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons

Table 7. Mismatches potentially developmental for age 5

	Acquired	**Potentially Developmental Errors**
Single Sounds		
Nasals	/m/, /n/ /ŋ/	
Stops	/b/ /d/ /p/ /t/ /k/ /g/	
Glides	/w/ /j/	
Fricatives	/f/ /v/ (F) /ð/ (I) /ʃ/ /h/ (GFTA-2 has /s/ and /z/ (I,M) by 5:0)	/v/ -> [b] ((I) /θ/ -> [f], [s], [t], [d] (I) /θ/ -> [f], [s] (F) /ð/ -> [d] (F) /s/ -> dentalized /z/ -> [d], [ts], [s], dentalized *Dental Distortion of /s/ and /z/*
Affricates	(GFTA has affricates by 4:6)	/ʧ -> [ts] (I, F) /ʤ/ -> [dz](I, F) *Fronting Palatals*
Liquids	/l/ (I) (GFTA has final /l/ by 5:0)	/l/ -> [w], [d] (intervocalic) /l/ -> vocalized (F) /r/ -> [w], derhotasized (distorted) (I) /r/ -> vocalized (F) *Gliding Liquids* *Derhoticized (Distortion) of /r/* *Vocalization of Liquids*
Clusters		
Stop + /w/	/tw/, /kw/	
Consonant + Liquid	/bl/ (boys 5:0) /fl/, /pl/, /kl/ (boys 5:6)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/ + Consonant	/sp/ (girls 5:0) /sw/, /sm/ /sk/) (girls 5:6) /st/ (boys 5:6)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/+Consonant + Consonant		Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons

Table 8. Mismatches potentially developmental for age 6

	Acquired	**Potentially Developmental Errors**
Single Sounds		
	Acquired	Potentially Developmental Errors
Nasals	/m/, /n/ /ŋ/	
Stops	/b/ /d/ /p/ /t/ /k/ /g/	
Glides	/w/ /j/	
Fricatives	/f/ /v/ /θ/ /ð/ (I) /s/ /z/ /ʃ/ /h/	/ð/ -> [d] (F) GFTA-2 doesn't have /θ/ or /ð/ until 7:0
Affricates	/tʃ,//dʒ/	
Liquids	/l/ GFTA has /r/ in all positions by 6:0	/r/ -> [w], derhotasized (distorted) (I) /r/ -> vocalized (F) *Gliding, Derhoticized /r/* *Vocalization of final /r/* *Derhotazation (Distortion)* *Vocalization of Liquids*
Clusters		
Stop + /w/	/tw/, /kw/	
Consonant + Liquid	/bl/ (boys 5:0) /fl/, /pl/, /kl) C + r (girls 6:0) /dr/, /kr/ (boys 6:0)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/ + Consonant	/sp/ (girls 5:0) /sw/, /sm/ /sk/) (girls 5:6) /st/ (all) /sn/, /sl/ (girls 6:0)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons
/s/+Consonant + Consonant	/skw/ (girls 6:0)	Cluster intact, but individual consonants may be affected by substitutions that affect them as singletons

Table 9. Developmental considerations for age 7 and above

No errors on single consonants
Boys may continue to make errors on consonants in /s/ + Consonant clusters and Consonant + /r/ clusters through Age 7
Both boys and girls may continue to make errors in consonants in /s/ + Consonant + Consonant through Age 8

Summary

Sound system disorders make up the largest part of speech-language pathology caseloads and have been shown to affect children in many areas besides speech (ASHA, 2003; Catts, 1993; Larrivee & Catts, 1999; Raitano et al., 2004; Rvachew et al., 2003; Bird, Bishop, & Freeman, 1995; Webster, Plante, & Couvillion, 1997). This thesis is meant to inform clinical decision making and give educational systems in Missouri the resources they need to identify and treat children with SSD. Charts were created to reflect reference data improvements in sampling methods and specificity (Smit et al., 1990; Smit, 1993a; Smit, 1993b). Additional reference information about standardized tests, intelligibility, percent consonants correct were provided to help IEP teams make decisions about children with questionable SSD eligibility.

Components to be Developed

Adverse Effects on Education

This section will discuss possible adverse effects on education resulting from sound system disorder.

Procedures for Differentiating Dialectal Variation from SSD

This section will explain procedures for differentiating dialectal variations from sound system disorders.

Tier 2 Instructional Procedures

This section will explain Tier 2 instructional procedures and possible differences in frequency of instruction, degree of repetition and review, and intensity of support

Tier 3 Instructional Procedures

This section will address target selection and treatment methods for sound system disorders.

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