Do attitudes and practice patterns predict the perception of children's speech? Evidence from a web-based audio survey of Speech-Language Pathologists.

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Abstract

Purpose. A speech sound disorder (SSD), as an atypical production of a speech sound or pattern of speech sounds characterized by distortion, substitution, omission, or addition that may interfere with intelligibility that persists beyond a particular age. Children who do not meet developmental milestones for speech sound production may be diagnosed with a SSD by a Speech-Language Pathologist (SLP). Accurate assessment and effective treatment for a child with a SSD relies heavily on the SLP's detailed perception of his or her speech sound productions. This thesis reviews the literature about adults' perception of children's speech, and the effect of clinical experience as an SLP on perceptive skills.

Method. The experiment is an online survey measuring 86 Speech-Language Pathologists from across the country. It measures their professional experience, as well as their attitudes and beliefs about the nature of SSDs, client characteristics, and clinical decisions. The survey compared clinicians' performance on a speech-sound rating task, across four consonant contrasts: stops /s/-/θ/ and /s/-/ʃ/, and fricatives /d/-/g/ and /t/-/k/.

Results. Clinicians with the most professional experience were less categorical in their ratings of stops than the least experienced clinician group. For fricatives, as professional experienced increased, clinicians were more attentive to the primary cues and less attentive to the secondary cues for speech production.

Conclusions. Professional experience leads to more reliable speech perception across speech sound categories; those with more experience have better perception of fine phonetic detail and rely more on the important information in the speech signal when perceiving speech sounds. Limitations and future research are discussed.

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Introduction

The American Speech-Language-Hearing Association defines a speech disorder of articulation, referred to as a speech sound disorder (SSD), as an atypical production of a speech sound or pattern of speech sounds characterized by distortion, substitution, omission, or addition that may interfere with intelligibility (1993). A child's productions are not considered atypical if they are related to the child's dialect or accent, for example /dIs/ for /θIs/ in speakers of African American Vernacular English. Given that speech sound development is gradual and that all children produce errors as they learn to speak, the meaning of "atypical" is determined by age. Children typically acquire different speech sounds at different ages, but most children are able to produce all the sounds of the English language by about 8 years of age (Smit, Hand, Freilinger, Bernthal, & Bird, 1990). Children who do not meet developmental milestones for speech sounds may be diagnosed with a SSD by a Speech-Language Pathologist (SLP). Accurate assessment and effective treatment for a child with a SSD relies heavily on the SLP's detailed perception of his or her speech sound productions. This thesis will review the literature about adults' perception of children's speech, and the effect of clinical experience as an SLP on perceptive skills. Using a two-part survey to measure clinicians' experience, beliefs, and practice preferences, as well as to measure their perceptive abilities, it explores the clinical factors that are associated with more accurate perception of children's speech.

Adult Perception of Children's Speech

As they are learning to talk, children receive speech input and, as shown in Julien and Munson (in press), feedback about their productions from adult caregivers. In the case of those receiving speech therapy, this feedback comes from a Speech-Language Pathologist. Therefore, adults' perceptions of children's speech productions have developmental and clinical importance. Julien and Munson (in press) reviewed the literature that suggests that the phonetic characteristics of adults' speech to children facilitate their learning of speech sounds. They subsequently found that adult listeners' child-directed productions of word-initial fricatives were longer, and therefore clearer, when they rated the child's productions to be inaccurate. Speech therapy for speech sound disorders relies on an SLP's perception of a child's speech to assess, diagnose, treat, and measure progress of speech sound disorders. The clinical and developmental implications necessitate study of how adults perceive speech.

Traditional research methods proposed that adults exhibit strict categorical perception of speech sounds. That is, when listeners use a forced-choice phoneme categorization system (/t/ or /k/) to rate a gradient of speech sound productions, their identification of phoneme category changed abruptly between intermediate productions, not gradually. Recently, others including Schouten, Gerrits, and van Hessen (2003) and Munson, Edwards, Schellinger, Beckman, and Meyer (2010) have offered that the finding of strict categorical perception is a result of the categorical task used to measure it. Similarly, using a phonetic system, literate adults describe speech sounds categorically. When writing an English word, they must decide whether they heard an "s" or an "sh" to know whether to record "sack" or "shack." Similarly, speech-language clinicians and

researchers use phonetic transcription, typically with the International Phonetic Alphabet (IPA), to record speech sounds in a fixed number of categories. When addressing gradual speech sound development, both typical and disordered, a categorical system may fall short of their needs.

An important concept in the study of speech sound development is that of *covert contrasts*. Munson et al. (2010) reviewed the research that has shown that during speech development, before children produce adult-like speech sound contrasts, they produce "covert contrasts," which are subcategorical but acoustically measurable differences in speech sound productions. Imagine a typically developing child whose productions of "see" and "she" at 24 months are acoustically and perceptually identical. When retested at 36 months, both productions are transcribed by adult listeners as "see," though there are acoustically measurable differences between her productions of the two words. By the time she reaches 60 months, her adult caregivers perceive both productions as correct. Evidence of covert contrasts during typical and atypical speech development has been provided for a number of different phoneme types, including the contrasts used in this thesis: /t/ versus /k/, /d/ versus /g/, /s/ versus "th," denoted by the IPA symbol /θ/, and /s/ versus "sh," denoted as /ʃ/. Forest, Weismer, Milenkovic, and Dougall (1988) found covert contrasts in the differentiation of /t/-/k/. Li, Edwards, and Beckman (2009) found a covert place contrast between the anterior sibilant fricatives (/s/-/ʃ/) in children acquiring both English and Japanese. Baum and McNutt (1990) found covert contrast between /s/ and /θ/ in children acquiring English. Although these fine differences in speech sounds are acoustically measureable, they are not easily perceptible to all adult listeners in some

listening tasks. The term *covert* implies that these small contrasts might be hidden from most listeners. However, the following studies and this thesis will discuss adults' considerable skills—and methods for measuring them—at perceiving these subcategorical differences in speech sounds. Therefore, it is appropriate to use the term *fine phonetic detail* in place of *covert contrast.*

Recent studies have focused on adults' perception of fine phonetic detail in children's speech using non-categorical methods. Munson et al. (2010) found that when adults were given a continuous, rather than categorical, system in which to record children's speech sound productions, they could rate intermediate speech sounds. The term *intermediate sounds* refers to productions that fall somewhere between two adult-like sounds, in a way that reflects the sounds' acoustic properties. For example, a sound that is intermediate between /s/ and /ʃ/ has acoustic characteristics that are intermediate between the /s/ and /ʃ/ endpoints. The continuous system used for these perception tasks was visual analogue scaling (VAS), in which listeners are asked to scale their auditory perception using an idealized visual display. The display is a line with two labeled endpoints (for example, "the 's' sound" at one end and "the 'sh' sound" at the other); listeners are asked to click a location on the line that represents where the speech sound production they heard falls on a continuum from /s/ to /ʃ/. Using this continuous system, Munson et al. (2010), Julien and Munson (in press), and Urberg-Carlson, Munson, and Kaiser (2009) showed that adult listeners demonstrate more sensitive perception of fine phonetic detail in children's speech than was shown by using the traditional forced-

choice design of the categorical perception studies. The aforementioned studies measured untrained adult listeners' perceptive abilities.

Speech Perception and Clinical Experience

SLPs will hear a wide range of speech sound production errors and approximations when working with children who have SSDs. The presence and perception of covert contrasts has clinical implications. Tyler, Figurski, and Langsdale (1993) found that children who demonstrate a covert contrast between targets make faster gains in therapy and generalize correct productions more readily than children who do not. With this in mind, a clinician's accurate perception of fine phonetic detail may impact clinical prognoses and therapy choices. If a clinician is able to perceive and record gradual changes in speech sound accuracy, she could better track progress during speech therapy.

Despite the clinical importance, only a small number studies examine the effect of clinical experience on adults' perception of typical and disordered speech. Wolfe, Martin, Borton, and Youngblood (2003) studied the phonetic perception of the /r/-/w/ contrast among Speech-Language Pathology graduate students both with and without clinical practicum experience. They found that students with practicum experience showed increased perceptual sensitivity to /w/ and that they were better able to identify whether a sound was closer to /r/ or /w/ than students without clinical experience. Conversely, Schellinger, Edwards, Munson, and Beckman (2008) studied the perception of /s/-/θ/ among graduate and undergraduate communicative disorders students. They found no significant group effect on listeners' categorizations of children's productions of /s/-/θ/.

Schellinger et al. offered that overlap in the amount of clinical experience between groups could have affected the findings (2008). Neither study measured highly experienced Speech-Language Pathologists. Using the VAS method, Munson, Johnson, and Edwards (2012) found that those with experience practicing as a Speech Language Pathologist had better perception of fine phonetic detail in children's speech than inexperienced listeners. They showed higher intra-rater reliability, less bias toward more frequent sounds, and their ratings related more closely to acoustic measurements of the children's speech sounds.

Purpose of the current study

The literature covered in this thesis has argued that children, during both typical and atypical development, produce speech sounds that fall between adult categories, that adults are better a perceiving these subcategorical differences than previously thought, and that clinical experience has an effect on adults' perception of fine phonetic detail in children's speech. What is it about clinical experience that makes SLPs more or less attuned to these clinically important sound contrasts? Surveys of SLPs who treat children who have SSDs reveal heterogeneity in their clinical experience and practices. Skahan, Watson, and Lof (2007) gathered responses from 312 Speech Language Pathologists who had experience assessing and treating children who have SSDs. With regard to assessment of SSDs, the authors found differences between clinicians in many areas, including the amount of time spent on different assessment tasks, assessment tools that were used, and methods of analyzing and reporting assessment results. Clinicians' responses showed that their direct assessment methods rely heavily on their perception

abilities and judgments. Estimation of intelligibility, administration of a single-word test, and assessing stimulability of errored sounds were direct assessment tasks rated as "always" used by a majority of respondents. Published articulation tests, such as the Goldman-Fristoe Test of Articulation, which require a clinician's judgment of production accuracy were reported as "always" used by 87.8% of clinicians.

It stands to reason that some clinicians may be better able to perceive fine phonetic detail in children's speech than others. The purpose of this thesis is to find out if these differences are reflected in their amount of clinical experience, their clinical preferences, and their attitudes and beliefs about the nature of SSDs, client characteristics, and clinical decisions. This study was developed as an online survey meant to measure a large cohort of Speech-Language Pathologists from across the country. It consists of a survey portion to measure their professional experience, including years of practice, types of clients served, and clinical setting, as well as an attitudes and beliefs measure in which they provide their agreement or disagreement to statements about the nature of SSDs, client characteristics, and clinical decisions. The survey is to be compared to clinicians' performance on a speech rating task, similar in design to the other VAS studies though having a nine-point scale, across four consonant contrasts: /s/-/θ/, /s/-/ʃ/, /d/-/g/, and /t/-/k/.

Research Questions and Predictions

The first research question is if clinician characteristics related to knowledge, experience, beliefs, and/or attitudes about clinical practice as an SLP relate to the ability to accurately rate fine phonetic detail in children's speech sounds, and if so, which

characteristics. To determine "accuracy," participant ratings will be compared to acoustic measurements of the children's speech sound tokens. Another question is if groups exist in SLPs with respect to these clinician characteristics, and if differences between groups are reflected in accuracy of ratings.

The size of the survey and the diversity of the questions create the possibility for a multitude of predictions and analyses. However, for the purpose of this thesis, predictions and analyses were constrained to the following: Regarding sound ratings overall, based on past studies of these speech sounds, one would expect that listener's ratings of fricative sound contrasts (/s/-/θ/ and /s/-/ʃ/) would be less categorical than stop consonants (/d/-/g/ and /t/-/k/). That is, we expected that participants would provide fewer endpoint (1 and 9) responses for the fricative stimuli than for the stop stimuli. We predict that this discrepancy will be mediated by experience: clinicians with more experience working with SSDs should exhibit less categorical, or more continuous, sound ratings of all contrasts than less experienced clinicians. Another prediction is that the survey data will allow us to participants into groups that hold similar beliefs and attitudes, and which have similar practice preferences. We further hypothesize that these groups will differ in their speech perception. These findings have clinical significance if they provide understanding as to what makes some clinicians better at speech perception than others. Although this study does not measure treatment outcomes, it may be that clinicians with better perception abilities are better able to measure progress and make more effective treatment decisions. If the results reveal that particular clinical practices are related to

better perception of covert contrasts, it would invite further study using these methods and possible eventual practice recommendations.

Method

This experiment was implemented with a secure web-based survey hosted by the University of Minnesota College of Liberal Arts survey service. All participants reported that they were Speech-Language Pathology clinicians with some level of experience treating children's speech sound disorders. The three-part online experiment consisted of: a clinical experience survey (Appendix A) including number of years, clinical settings, and populations served, an attitudes and beliefs survey (Appendix B) about clinical practice choices and the nature of SSDs, and a listening task to measure participants' accuracy of speech sound perception ratings.

Development of Attitudes and Beliefs Survey

The statements on the attitudes and beliefs survey were developed following a focus group discussion with four SLPs who treat children with SSDs in different age groups: birth to three years, preschool, elementary school, and middle through high school. The focus group was guided to discuss both the group members' own clinical beliefs and preferences as well as those they had heard from other clinicians on the following topics: the nature of SSDs, population characteristics of children with SSDs, use of assessments, approaches to treatment, and phonetic transcription. For the discussion, each topic was separated into guided conversation starters that were meant to capture prevalent, opposing, or controversial ideas present among SLPs. For example, the

scripted conversation starters for the section on the use of assessments included "What types of assessment do you find most useful for SSDs? Which do you find not useful? Talk to me about opinions on types of assessments you've heard from other professionals, that you may or may not agree with yourself." From the discussion, researchers designed the survey statements to capture potential clinician differences that were identified by the focus group discussion.

Listening Task Stimuli

The stimuli were children's productions of sound from four contrasts: /t/-/k/, /d/-/g/, /s/-/ʃ/, and /s/-/θ/. These contrasts were chosen because they are commonly neutralized by children during normal phonological development. The productions were taken from the παιδολογος (paidologos) database of children's speech (see Edwards and Beckman (2008a, 2008b) and Li et al. (2009) for complete description). Monolingual English-speaking 2-through-5 year-old children were recorded during a picture prompted real word and non-word repetition task. They were shown pictures of familiar or novel objects along with an audio recording of the real or non-word, and then asked to repeat what they heard. Using a Praat software script, the recordings were shortened to include only the initial consonant-vowel sequence (Boersma & Weenink, 2005).

All stimuli were transcribed by a trained phonetician, who judged them to be either correct or intermediate productions between the respective contrast pairs. The intermediate transcription groups were consistent with the guidelines in Stoel-Gammon (2001) for transcription of speech of children with speech sound disorders. As described in Arbisi-Kelm, Beckman, Kong, and Edwards (2008), Arbisi-Kelm, Edwards, Munson,

and Kong (2010), and Munson et al. (2010), the stimuli were also analyzed using psychoacoustic measures of the spectra of the stop bursts and the intervals of frication, which are based on models of human hearing. The psychoacoustic measures were found to differ as a function of transcription category, with some overlap. Munson et al. (2012) explain that these psychoacoustic measures parallel the transcription categories, and should be used independently to describe the stimuli.

From the paidologos recordings, 15 English tokens were chosen from each contrast. The selected tokens were meant to be representative of the entire contrast continua, and were selected from evenly spaced intervals of rank-order average VAS rating from previous studies. Average VAS ratings of the /s/-/ʃ/ sounds were taken from Julien and Munson (in press). Average VAS ratings for the other contrasts were taken from the inexperienced listener ratings in Munson et al. (2012)./t/-/k/ and /d/-/g/ tokens were also balanced for front or back vowel contexts, as the nature of this place contrast differs substantially as a function of following vowel context.

Participation and Recruiting

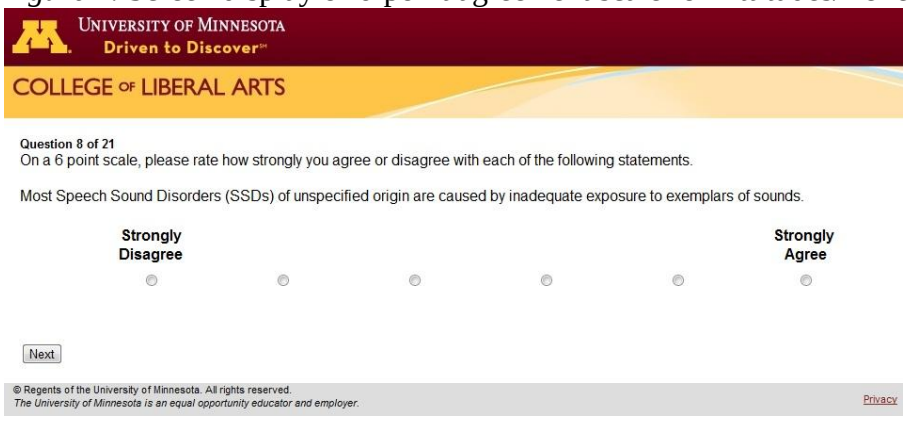
Clinicians were recruited by email through speech-language-hearing state association listservs, social networking websites, and by word-of-mouth from colleagues and other participants. Recruitment emails called for a large cross-section of speech-language pathologists from across the United States with all levels of experience who diagnose and treat children with speech sound disorders to participate. Those who wished to participate emailed researchers to request a link to the online experiment and a participant ID. 86 clinicians logged in to the online survey to participate and completed

the survey portion. Five clinicians' perception data were not included in analysis due to self-reported problems accessing or hearing the listening task audio files. Participants completed both surveys and the listening task online from their own computers using speakers or headphones.

Online Experiment

Participants used their assigned ID code to log-in to the online experiment. They indicated their consent to participate on the first screen of the experiment. After consenting, participants read a brief introduction to the experiment and instructions for completing the survey. For the attitudes and beliefs survey, participants were told to respond with how strongly they agree or disagree with statements about their clinical practice with children's SSDs. Participants used a 6-point agreement scale, with no neutral point (see Figure 1). Instructions stressed that there were no right or wrong answers, but that responses were their own opinions (see Appendix C for complete view of survey instructions).

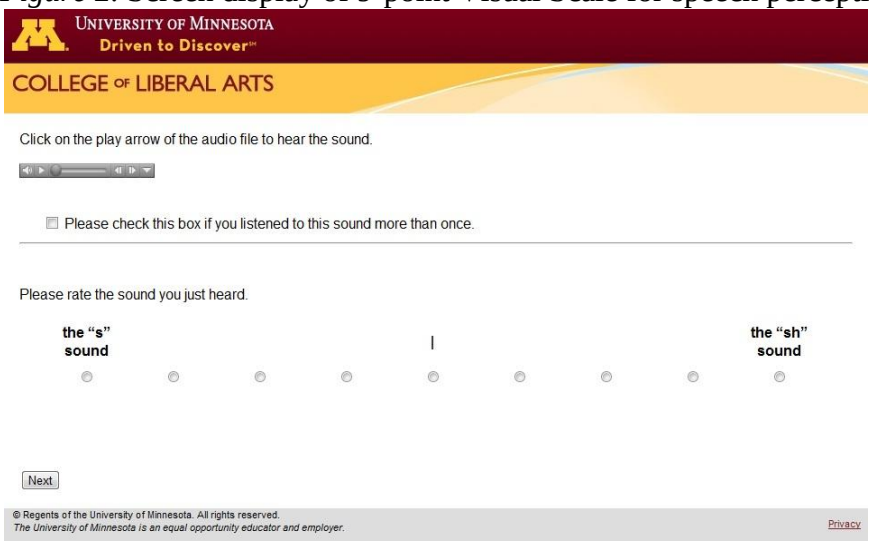
Figure 1. Screen display of 6-point agreement scale for Attitudes/Beliefs survey.



The listening task followed the survey portion of the experiment. Participants read that they would be hearing speech sounds produced by children in various stages of

speech development, with varying levels of accuracy. For each contrast, participants were told to rate the speech sound by clicking on a 9-point line (see Figure 2) with end points labeled “the ‘s’ sound” and “the ‘sh’ sound” (for the /s/-/ʃ/ contrast).

Figure 2. Screen display of 9-point Visual Scale for speech perception task.



If participants heard a perfect “s” or perfect “sh,” they were to click on the endpoint; if they heard an intermediate sound, they were to click a point on the line which corresponded to how s-like or sh-like the sound was produced. Participants were urged to use the entire line in making their ratings. Items were blocked by contrast, ordered /s/-/ʃ/, /d/-/g/, /t/-/k/, and /s/-/θ/. Participants reviewed the instructions and completed two practice questions before each contrast (see Appendix D for complete view of listening task instructions).

Survey response data was saved by participant ID through the University of Minnesota CLA survey service. Survey responses and sound ratings were exported to an Excel spreadsheet for analysis, identified by participant ID.

Results

Experience and Attitudes/Beliefs Survey Responses

Years of experience among clinicians was measured using five groups: less than 5 years, 5-10 years, 11-15 years, 16-20 years, and more than 20 years. Median years of reported experience as a speech-language pathologist was 5-10 years, and median years working with clients having speech sound disorders was 11-15 years (see Table 1).

Table 1.

Clinician reported years of experience, n=81

	<5 years	5-10 years	11-15 years	16-20 years	>20 years
Experience working as an SLP	16	26	13	8	18
Experience working with SSDs	17	23	16	8	17

One reason for this discrepancy is that clinicians may have included their undergraduate and graduate clinical experience when counting work with clients who have SSDs. Most participants reported experience working in school settings (see Table 2). Most clinicians reported having worked with elementary aged children having SSDs (see Table 3). The highest number of clinicians reported that 41%-60% of their caseloads include treatment for SSDs (see Table 4).

The most commonly reported disorders co-occurring in clients with SSDs were Language Delay, Learning Disabilities, and Autism Spectrum Disorders (ASD). Attention Deficit Hyperactivity Disorder (ADHD) and Childhood Apraxia of Speech (CAS) were also commonly reported as co-occurring in clients with SSDs (see Table 5). While some statements on the attitudes/beliefs questionnaire showed clear trends of agreement or disagreement across all clinicians, others elicited a more divided pattern of

responses, allowing for identification of clinician groups. Table 6 contains a summary of all responses to the Attitudes/Beliefs Questionnaire.

Table 2.

*Clinical settings, n=81**

Setting	*n*	%
School	63	77.8%
Private Clinic	12	14.8%
University Clinic	7	8.6%
Hospital	6	7.4%
Home Environment	4	4.9%
Nursing Facility	1	1.2%
Multiple Settings	13	16.0%

*Some participants indicated multiple settings.

Table 3.

*Clinicians reporting ages of SSD clients, n=81**

Age group	*n*	%
0-4 years (Preschool Age)	67	82.7%
5-10 years (Elementary Age)	75	92.6%
11-14 years (Middle School Age)	52	64.2%
15-18 years (High School Age)	35	43.2%

18+ years (Adult)	23	28.4%
*Some participants indicated multiple age groups.		

Table 4.

Clinicians' caseloads working with SSDs, n=81

	Reported Percentage				
	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Percent of caseload that includes SSD treatment	11	14	32	16	7
Percent of SSD clients with co-occurring disorders	20	29	13	11	6

Table 5.

Clinicians reporting co-occurring disorders in SSD clients, n=81*

Co-occuring disorder	*n*	%
Language Delay	68	84.0%
Learning Disabilities	63	77.8%
Autism Spectrum Disorders (ASD)	62	76.5%
Attention Deficit Hyperactivity Disorder (ADHD)	59	72.8%
Childhood Apraxia of Speech (CAS)	58	71.6%
Down Syndrome	50	61.7%
Hearing Loss	47	58.0%

Mental Retardation	37	45.7%
Physical Disabilities	33	40.7%
Fluency Disorders	31	38.3%
Brain Injury	16	19.8%
Personality and Mood Disorders	14	17.3%

Table 6.

Responses from Attitudes and Beliefs Questionnaire, n=81

Statement	Number of clinician responses					
	Strongly Disagree (1)	(2)	(3)	(4)	(5)	Strongly Agree (6)
1. Most Speech Sound Disorders (SSDs) of unspecified origin are caused by inadequate exposure to exemplars of sounds.	23	42	9	5	2	0
2. Most SSDs of unspecified origin are caused by imprecise motor learning/planning of speech sounds.	1	10	16	22	25	7
3. I can differentially diagnose Childhood Apraxia of Speech from a phonological disorder.	2	7	10	14	33	15
4. Most SSDs are related to a language problem.	24	29	11	13	3	1
5. Children with SSDs are unaware that others cannot understand them.	6	34	17	14	9	1

6. Most children with SSDs are unskilled self-monitors as compared to their peers.	2	16	25	16	16	6
7. Most children with SSDs will have future language/literacy problems.	5	22	20	25	8	1
8. Children with SSDs have trouble making friends, and withdraw from social situations.	13	33	15	13	5	1
9. Challenging behaviors of children with SSDs are due to breakdowns in communication of wants/needs.	0	8	12	33	22	6
10. Phonetic transcription must be used for assessment of SSDs.	3	9	7	13	29	20
11. Standardized assessments must be used for assessment of SSDs.	6	6	15	12	27	14
12. Phonetic transcription is the most useful tool for tracking progress of speech sounds during the course of treatment.	3	17	21	20	13	7
13. Correct/incorrect marks are the most useful tool for tracking progress of speech sounds during the course of treatment.	5	6	10	25	23	12
14. My own descriptions are the most useful tool for tracking progress of speech sounds during the course of treatment.	1	10	10	24	28	8

Effect of Clinical Experience on Listening Task Responses

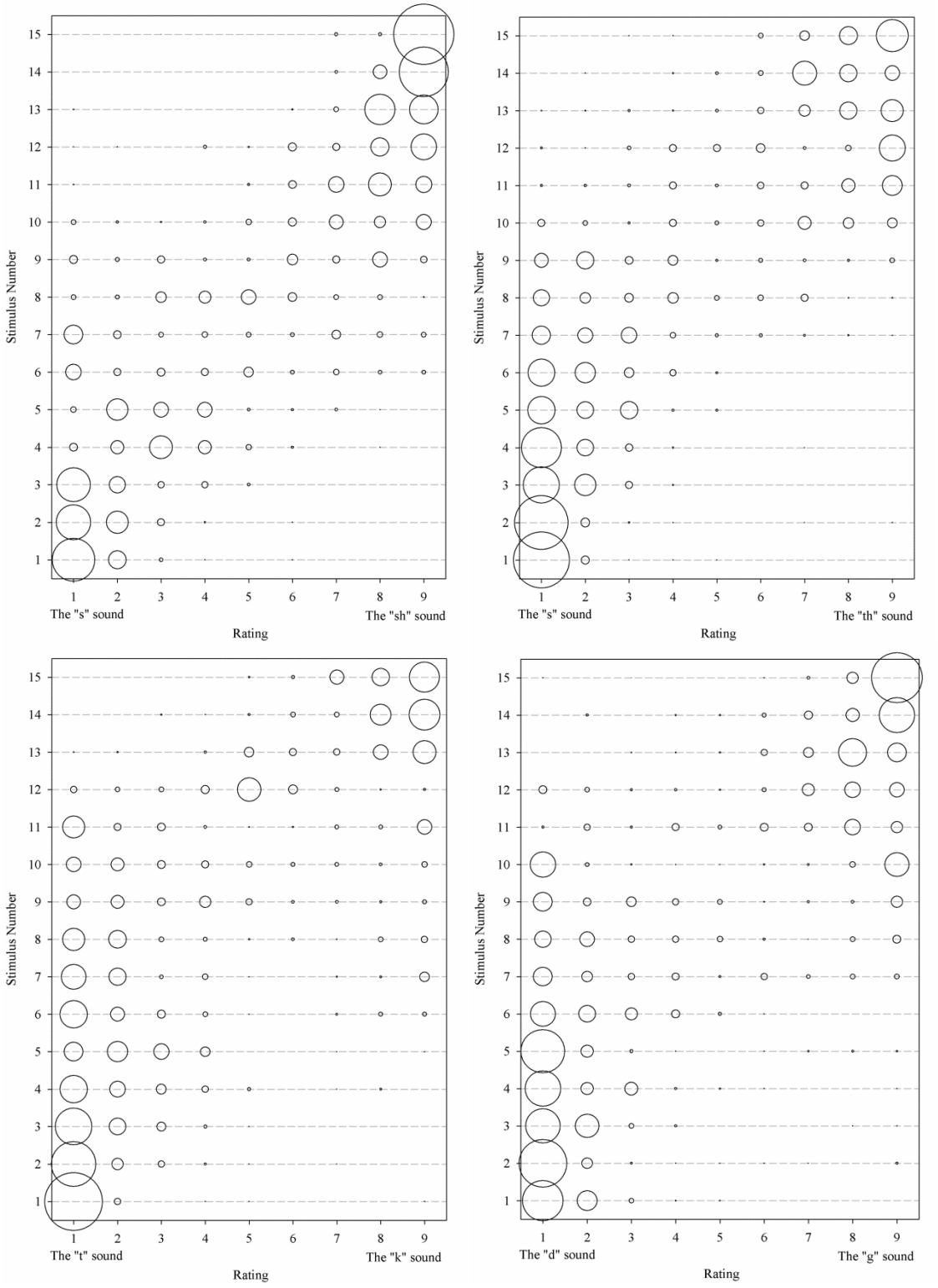
As reported in Table 1, two years-of-experience measures were gathered. Because this study aims to measure the effect of professional clinical experience on speech

perception, experience groups were compared based on clinicians' reported experience as an SLP.

Categoricity across contrasts and clinical experience.

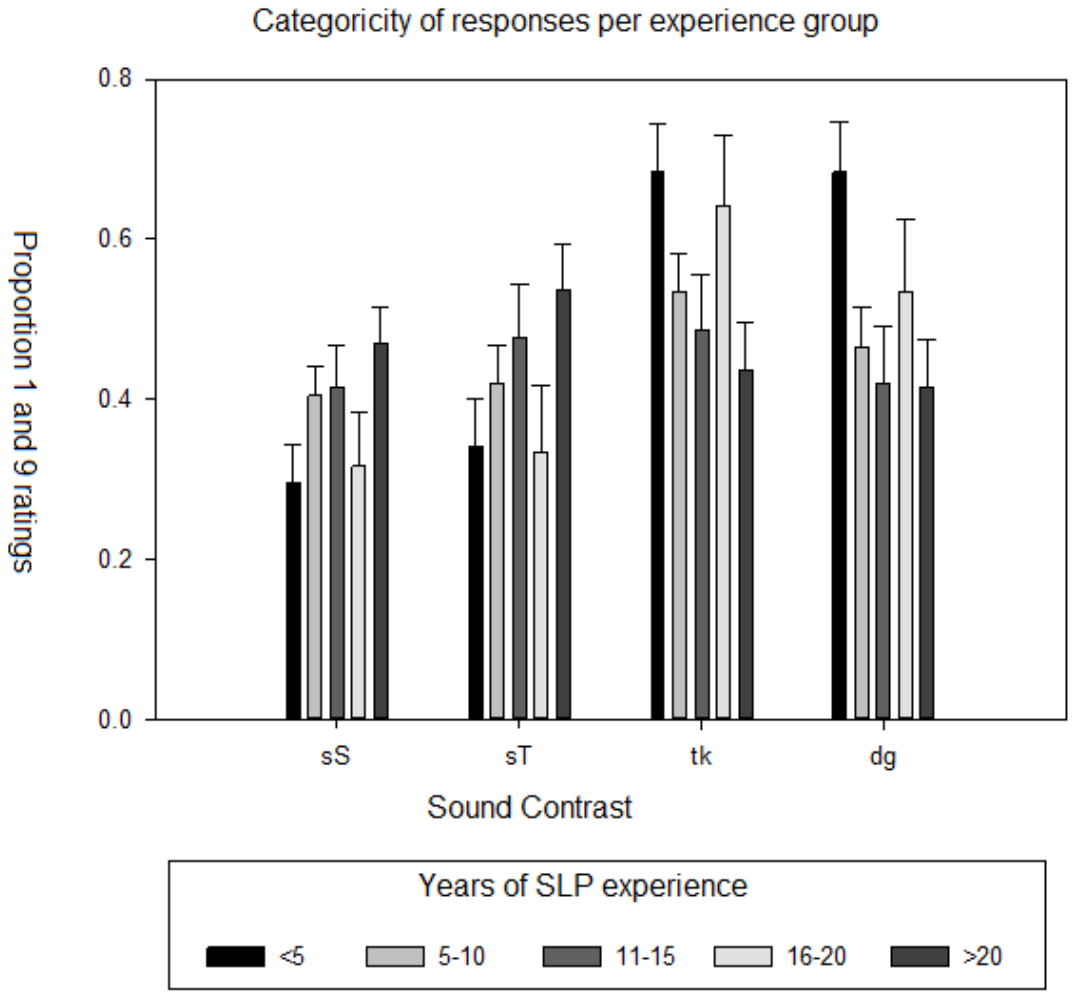
One expectation was that listener's ratings of fricative sound contrasts (/s/-/θ/ and /s/-/ʃ/) would be less categorical than stop consonants (/d/-/g/ and /t/-/k/), reasoning that they would elicit more responses in the mid-range of the scale. The knowledge behind this prediction is that for fricative contrasts, relatively large articulatory changes bring about smaller perceptual differences. Conversely for stop contrasts, relatively small articulatory changes, namely tongue placement, bring about large perceptual differences. Figure 3 shows a bubble plot representation of listener responses by token, across all participants.

Figure 3. Bubble plot of all VAS ratings for /s/-/ʃ/, /s/-/θ/, /t/-/k/, and /d/-/g/.



Our prediction that fricative ratings would be less categorical was true only for the group of listeners with the least experience as SLPs. Therefore, these results correspond to the prediction that clinicians with more experience would exhibit less categorical, or more continuous, sound ratings across contrasts than less experienced clinicians. Results of a multivariate analysis of variance (MANOVA) showed that the clinical experience significantly affected the categoricity of the ratings of /t/-/k/ and /d/-/g/ ($F[4,76] = 2.616$, $p = 0.042$, partial $\eta^2 = 0.121$ for /t/-/k/; $F[4,76] = 3.034$, $p = 0.022$, partial $\eta^2 = 0.138$ for /d/-/g/), such that those with the more experience gave fewer 1 and 9 responses for /t/-/k/ and /d/-/g/ speech sounds than did their less experienced counterparts. Post hoc analyses revealed that this effect was driven by differences between the least experienced and most experienced groups (see Figure 4). The effect for /s/-/ʃ/ did not achieve statistical significance at the conventional $p < 0.05$ level, but did approach this, ($F[4,76] = 2.245$, $p = 0.072$, partial $\eta^2 = 0.106$). As Figure 4 shows, the least experienced group exhibited a gap in the categoricity of their responses, in that they used more 1 and 9 responses in their ratings of stops than in fricatives. Contrastively, the most experienced group's categoricity remained largely stable across sound contrasts. With the exception of group 4, 16-20 years of experience as an SLP, the other groups fall between the least and most experienced group for this effect. This may be due to the small n=8 of group 4. This finding suggests that more experienced SLPs' perceptions of fine phonetic detail are more reliable across speech sound categories than those of their less experienced counterparts.

Figure 4. Proportion of categorical responses by contrast, per experience group



Accuracy of ratings and clinical experience.

Predictions about years of experience focused on categoricity of the SLPs' ratings. However, how closely their VAS ratings matched the acoustic properties of the speech sound tokens should also be explored. Across all listeners, ratings of the stop consonants, /t/-/k/ and /d/-/g/, were strongly correlated with the original VAS ratings, taken from Munson et al. (2012). However, no statistically significant differences between experience groups in how closely matched to acoustic measurements were found

for these contrasts. One explanation for this may be that there is currently no reliable acoustic measure for stop placement. Given that stop consonants are among the earliest learned speech sounds, this is another reason that acoustic measurement for SSDs is not clinically feasible at this time.

The fricative consonants, /s/-/ʃ/ and /s/-/θ/, each have two acoustic predictors, a primary cue and a secondary cue. As used in Li et al. (2009), the primary cue for /s/-/ʃ/ is centroid frequency (the frequency at which there is a peak in energy); the secondary cue is second formant frequency of the following vowel at vowel onset. As used in Munson et al. (2010), the primary cue for /s/-/θ/ is relative intensity of the fricative compared to the following vowel; the secondary cue is compactness of the fricative spectrum. For each listener and for each contrast, a simple linear regression was conducted predicting their responses (ratings) from those two acoustic predictors. Each regression produces three data points: the strength of relation between response and acoustics (r^2), and a measure of slope for each cue. Results for /s/-/θ/ showed that experience significantly affected the coefficient for relative intensity ($F[4,76] = 3.642$, $p = 0.009$, partial $\eta^2 = 0.161$) and the coefficient for spectral compactness ($F[4,76] = 3.391$, $p = 0.013$, partial $\eta^2 = 0.151$). This finding suggests that clinical experience increases attention to the primary cue for /s/ versus /θ/ and decreases attention to the secondary cue. This effect, increased attention to primary cue and decreased attention to secondary cue with experience, was also shown for /s/-/ʃ/, but the differences did not achieve statistical significance. There was a statistically significant decrease in the r^2 value for /s/-/ʃ/ with experience. As experience increased, less variance could be accounted for by the acoustic predictors.

Attitudes/Beliefs and Listening Task Responses

Clinician groups by practice preferences.

Another prediction was to find groups among clinicians, in that those with similar beliefs and attitudes will have similar practice preferences. Statements 1-2 (see Appendix C for the complete survey) stated beliefs about the cause of speech sound disorders. Statements 4-9 stated beliefs about cognitive and behavioral characteristics of children with SSDs. Table 6 contains a summary of all participants' responses to the Attitudes/Beliefs survey. As indicated by statement 3, there was a clear agreement trend among participants that they could differentially diagnose Childhood Apraxia of Speech from a phonological disorder, with 62 (76.5%) clinicians indicating agreement and only 2 indicating strong disagreement. Statements 10 and 11 addressed the use of phonetic transcription and standardized testing for the assessment of SSDs. A clear agreement trend was found for both statements, with 62 clinicians agreeing that phonetic transcription must be used and 53 clinicians agreeing that standardized tests must be used.

Statements 12-14 on the Attitudes and Beliefs survey addressed preferred methods for tracking progress of speech sounds during the course of treatment. These statements elicited more divided response patterns, arguably because they could be viewed as alternative practice preferences and contained "most" statements. For the same reasons, clinicians were grouped based on their responses to Statements 12-14. Item 12 stated that phonetic transcription is the most useful tool for tracking progress, item 13 stated that correct/incorrect marks are most useful, and item 14 stated that "my own

descriptions" are the most useful tool for tracking progress. Of the 81 participants, 13 (16.05%) indicated strongest agreement for phonetic transcription, 23 (28.4%) indicated strongest agreement for correct/incorrect marks, and 24 (29.63%) indicated strongest agreement for their own descriptions being the most useful tool for tracking speech sounds during treatment. Twenty-one participants (25.93%) did not indicate a singular preference for a tool to measure speech sound progress.

Comparisons of the practice groups' responses to the attitudes and beliefs statements were made using a one-way ANOVA. Against prediction, no significant differences between groups were found for any of the other statements.

Practice preference groups and listening task responses.

These practice groups were also compared by categoricity of their speech perception responses. Using a Multivariate Analysis of Variance (MANOVA) to examine whether categoricity of responses differed as a function of progress category, there were no significant differences between any of the four groups.

To compare progress groups by how closely their listening responses matched the acoustic characteristics of the speech tokens, a parallel analysis to that of the experience groups was conducted. The results were not statistically significant, and therefore, will not be reported here.

Discussion

Principal findings

This section considers the findings with respect to our research questions, as well as their implications for clinical practice and future research. One prediction was that

participants' ratings of fricative sound contrasts (/s/-/θ/ and /s/-/ʃ/) would be less categorical than their ratings of stop consonants (/d/-/g/ and /t/-/k/), exhibiting more responses in the mid-range of the scale. Consider the knowledge driving this prediction: large changes in articulation (tongue placement) for fricative contrasts bring about smaller perceptual differences; small changes in articulation for stop contrasts bring about large perceptual differences. Therefore, perception of fine phonetic differences in stop contrasts is a more difficult task. Interestingly, this pattern was found only for the least experienced group of SLPs. This finding relates to the prediction that more experienced SLPs would show less categorical ratings than their less experienced counterparts. Clinicians with the most professional experience were less categorical in their ratings of /t/-/k/ and /d/-/g/ than the least experienced clinician group. This finding indicates that professional experience leads to more reliable speech perception across speech sound categories; those with more experience have better perception of fine phonetic detail in more difficult tasks.

Comparing the experience groups' ratings to the speech tokens' acoustic properties allows us to explore what information clinicians might be using to perceive small articulatory changes. For /s/-/θ/ and, though lacking statistical significance, for /s/-/ʃ/, as professional experienced increased, clinicians were more attentive to the primary cues and less attentive to the secondary cues for speech production. This suggests that with more professional experience, SLPs rely more on the important information about how children are articulating speech sounds, and are able to ignore the supplemental information in the speech signal. Although there is currently no reliable acoustic measure

of tongue placement for stops, experienced SLPs may be using a similar method to make their more continuous perceptions of stop contrasts.

Speech-Language Pathologists with more professional experience show more accurate and reliable perceptions of children's speech sound productions across speech sound types. The clinical implications of these findings are clear. A clinician with better perception can conduct a more accurate assessment of a child's speech sound disorder; if she is able to perceive covert contrasts between a child's production errors, she can make a more accurate prognosis for treatment. As the child progresses through speech therapy, an experienced clinician who perceives small gains in speech production will be better able to provide feedback to shape the child's productions, leading to more efficient learning of target behaviors.

By measuring perceptive abilities in clinicians with differing amounts of professional experience, it appears that SLPs learn perceptual skills in practice that are not taught in graduate school. Their theoretical beliefs and the clinical practices they employ may give insight into how this learning takes place. One prediction was to find groups among clinicians, in that those who hold similar attitudes and beliefs would employ similar practice preferences.

With respect to assessment practices, relative homogeneity was found among clinicians with agreement that phonetic transcription and standardized tests must be used to diagnose children's SSDs. This finding was expected for two reasons: Most participants in this study are school clinicians, whose state education departments may effectively necessitate the use of standardized tests as part of a diverse evaluation to

qualify children for school-based services, consistent with The Individuals with Disabilities Education Act (IDEA). Health insurance companies often use similar standards to qualify a child for coverage for treatment in hospital or private practice settings. Secondly, the highly used assessments in Skahan et al. (2007) use phonetic transcription.

Conversely, there was much more diversity among clinicians in the systems with which they track progress during the course of treatment. Although clinicians largely agreed that phonetic transcription must be used during assessment, preference for using phonetic transcription in tracking progress was indicated by the fewest clinicians. The largest number of clinicians preferred to use their own descriptions to track speech sound progress. This finding speaks to the difficulty of using categorical systems to record subcategorical detail in speech sound productions. In comparing these practice groups by categoricity and accuracy of their listening task responses, no statistically significant differences were found. By these measures, it seems that there is no gold standard of recording subcategorical progress currently in use by clinicians. Given the clinical importance of accurate measurement of and feedback for gains in sound production, this strongly invites future research into how best to measure and record small gains in speech sound productions.

Limitations and Future Research

In applying these and future findings using this data to clinical practice, one must be mindful of their limitations: First, although responses were gathered nationally, 86 clinicians is a relatively small sample. Only those who are members of state organizations

willing to distribute recruitment information could be reached. The online design of the survey further limited the participant pool to those clinicians comfortable using technology. A second limitation relates to the speech stimuli, in that they consisted of word parts. During typical assessment and treatment, clinicians hear speech sounds in the more complex context of words or phrases and are provided with visual information. As did Munson et al. (2012), one could predict that more experienced listeners' perceptual ability would remain stable across levels of complexity. This is supported by the finding that more experienced SLPs were more likely to attend to the primary cue when rating speech sounds, while decreasing their attention to the supplemental information in the speech signal.

This project is unique in that, to our knowledge, it is the first to measure differences in *professional* Speech-Language Pathology experience as compared to skill at perceiving fine phonetic detail in children's speech. This experiment generated a wealth of data; the analyses in this thesis were focused on the above predictions. Having discussed the impact of professional experience on perceptual skill and its clinical importance, future research using this data needs to explore the beliefs and practice patterns of the experienced groups of clinicians. Future researchers may find that SLPs with the most accurate and reliable perceptual abilities employ similar techniques to measure progress during treatment. Through experience they may have gained particular insights and beliefs about clients and clinical practice that affect the practices they use.

The paidologos speech tokens have been used previously in a number of published studies, including Arbisi-Kelm et al. (2010), Munson et al. (2012), and Julien

and Munson (in press), all of which used a sound-controlled listening environment in a research laboratory. This project was the first to use an off-site web-based presentation of these stimuli. Because many of the participants were recruited using their professional email addresses, it is reasonable to expect that many of them completed the survey in a setting similar to that in which they see clients. This method is useful for reaching and measuring responses from a large and geographically diverse group of participants. The finding that ratings of the stop consonants were strongly correlated with the original VAS ratings in Munson et al. (2012) limits speculation that listening environment might confound the results. A laboratory replication of this experiment may provide further support for a web-based presentation of speech research experiments.

This thesis presents the clinical importance of Speech-Language Pathologists' accurate and reliable perception of fine phonetic detail in children's speech productions and serves as a step toward understanding the effect of professional experience on perceptual skill. Further trial of an on-line design is warranted, so that it might be utilized to represent and include more clinical professionals in research. It is our hope that other investigators are drawn to further explore the specifics of clinical practice, so that this line of study might culminate in evidence-based recommendations to improve assessment and treatment methods for children with speech sound disorders.

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Appendix A. Clinical Experience Survey Questions

1. How many years of experience do you have working as a Speech Language Pathologist:

a. <5 years	b. 5-10 years	c. 11-15 years	d. 16-20 years	e. >20 years

2. How many years have you worked with clients who have Speech Sound Disorders (SSDs)?

a. <5 years	b. 5-10 years	c. 11-15 years	d. 16-20 years	e. >20 years

3. In what type of site do you (or did you) see clients with SSDs?

a. School	b. Hospital	c. Private Clinic	d. University Clinic	e. other, please specify:

4. What ages of clients with SSDs do you (or have you) seen? Please select all that aply.

	0-4 years (Preschool Age)
	5-10 years (Elementary Age)
	11-14 years (Middle School Age)
	15-18 years (High School Age)
	18+ years (Adult)

5. What percent of your client caseload includes treatment for speech sound disorders?

a. 0-20%	b. 20%-40%	c. 40%-60%	d. 60%-80%	e. 80%-100%

6. Of your clients with SSDs, what percent have other co-occurring speech, language, or cognitive disorders?

a. 0-20%	b. 20%-40%	c. 40%-60%	d. 60%-80%	e. 80%-100%

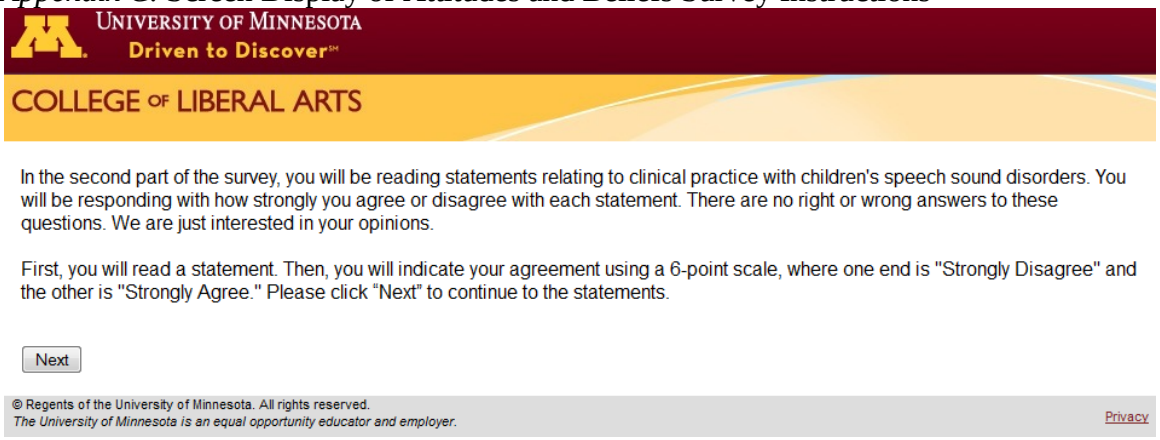
7. What types of co-occurring conditions do your clients with SSDs have? Please select all that apply.

	Autism Spectrum Disorders (ASD)
	Childhood Apraxia of Speech (CAS)
	Learning Disabilities
	Attention Deficit Hyperactivity Disorder (ADHD)
	Mental Retardation
	Down Syndrome
	Physical Disabilities
	Brain Injury
	Language Delay
	Hearing Loss
	Fluency Disorders
	Personality and Mood Disorders
	Other. Please Specify: _____

Appendix B. Clinical Attitudes and Beliefs Survey Questions

On a 6 point scale, please rate how strongly you agree or disagree with each of the following statements.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
1. Most Speech Sound Disorders (SSDs) of unspecified origin are caused by inadequate exposure to exemplars of sounds.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
2. Most SSDs of unspecified origin are caused by imprecise motor learning/planning of speech sounds.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
3. I can differentially diagnose Childhood Apraxia of Speech from a phonological disorder.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
4. Most SSDs are related to a language problem.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
5. Children with SSDs are unaware that others can not understand them.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
6. Most children with SSDs are unskilled self-monitors as compared to their peers.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
7. Most children with SSDs will have future language/literacy problems.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
8. Children with SSDs have trouble making friends, and withdraw from social situations.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
9. Challenging behaviors of children with SSDs are due to breakdowns in communication of wants/needs.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
10. Phonetic transcription must be used for assessment of SSDs.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
11. Standardized assessments must be used for assessment of SSDs.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
12. Phonetic transcription is the most useful tool for tracking progress of speech sounds during the course of treatment.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
13. Correct/incorrect marks are the most useful tool for tracking progress of speech sounds during the course of treatment.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree
14. My own descriptions are the most useful tool for tracking progress of speech sounds during the course of treatment.	|--------|--------|--------|--------|--------| Strongly Disagree Strongly Agree

Appendix C. Screen Display of Attitudes and Beliefs Survey Instructions



Appendix D. Screen Display of Listening Task Instructions (for /s/-/ʃ/)