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Facilitating Early Identification through Caregiver Report of Emerging Speech Patterns Using the Speech Sound Development Screener (SSDS)

By

Jill McDonald

A thesis to be

submitted in partial fulfillment

of the requirements for the degree of

Master of Science in the Department of Communication Sciences and Disorders

Idaho State University

May, 2023

Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of JILL McDONALD find it satisfactory and recommend that it be accepted.

Heather L. Ramsdell-Hudock, PhD CCC-SLP

Major Advisor

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Committee Member

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Graduate Faculty Representative

January 27, 2021

Heather Ramsdell-Hudock
Speech-Language Pathology
College of Rehabilitation Comm Sciences

RE: Study Number IRB-FY2021-97: Exploration of a Caregiver Report Screening Instrument for Infant Speech Patterns

Dear Dr. Ramsdell-Hudock:

I have reviewed your application for revision of the study listed above. The requested revision involves:
We have not yet received permission from Brooke's Publishing to electronically reproduce a subscale of the Communication and Symbolic Behavior Scales – Developmental Profile (CSBS-DP), yet we would like to move forward with this research project. Accordingly, the primary change proposed is to remove the CSBS-DP from the study until the publisher provides appropriate permissions. Here are edited sections of the approved IRB corresponding to proposed changes and including 3 new feasibility questions on the survey (edited Informed Consent and Survey document attached):

#7. The purpose of this project is to conduct an initial exploration of the Speech Sound Development Screener, an assessment tool for caregiver report of infant speech patterns, by administering the screener to a random sample of participants (number unknown) and exploring responses for developmental patterns, developmental status as typically developing or at risk, and feasibility. The Speech Sound Development Screener was created using commonly reported sounds/sound sequences from caregiver report of infant speech from 26 families. We will distribute an electronic survey link via social media for families with infants between 7 to 18 months of age, requesting information on infant developmental milestone and demographics, as well as completion of the Speech Sound Development Screener. The screener results will be used to begin exploring utility of the new tool. We expect that the Speech Sound Development Screener will be sensitive to infant age and developmental status as typically developing or at risk. Practical implications for study results would support continued evaluation and beginning validation of the Speech Sound Development Screener. We hope to someday provide a clinical tool that can facilitate earlier identification of children considered at-risk for speech sound disorders/delays, enable use in clinical or home settings with or without professional administration, and support more efficient methods of assessment for speech-language pathologist.

#14. A link to a Qualtrics survey will be used to elicit responses from families who have infants between 7 to 18 months of age. This link will be distributed via Idaho State University email addresses (to faculty, staff, and students across the university) and social media (e.g., to parent groups on Facebook). The survey will include: a letter explaining the research project, a question requesting informed consent and granting permission to use data for research purposes, 132 simple questions from the Speech Sound Development Screener (including feasibility focused questions, like how long did it take you to complete this survey), 32 questions to track demographic information, and 3 feasibility questions. Caregivers will be asked to complete and submit responses to survey questions. No identifying information will be collected; however, respondents will be given the opportunity to provide contact information if they would like to receive clinical results of completed materials. If respondents choose to provide contact information, a list of community resources for further assessment (e.g., Bloom Therapy, the Idaho Infant Toddler Program, the Idaho State University Speech and Language Clinic, Speech Therapy Services, LLC, etc.) will be provided to caregivers of children who indicate concern about their infant's development. Families can participate in the research, even if they chose not to provide contact information.

Study Information D. To recruit participants, we will distribute a link to a Qualtrics survey intended to elicit responses from families who have infants between 7 to 18 months of age. This link will be distributed via Idaho State University email addresses (to faculty, staff, and students across the university) and social media (e.g., to parent groups on Facebook). All families with infants between 7 and 18 months of age who choose to complete the survey will be included as study participants. The survey will include: a letter explaining the research project, a question requesting informed consent and granting permission to use data for research purposes, 132 simple questions from the Speech Sound Development Screener (including feasibility focused questions, like how long did it take you to complete this survey), 32 questions to track demographic information, and 3 feasibility questions. Caregivers will be asked to complete and submit responses to survey questions. No identifying information will be collected; however, respondents will be given the opportunity to provide contact information if they would like to receive clinical results of completed materials. If respondents choose to provide contact information, a list of community resources for further assessment (e.g., Bloom Therapy, the Idaho Infant Toddler Program, the Idaho State University Speech and Language Clinic, Speech Therapy Services, LLC, etc.) will be provided to caregivers of children who indicate concern about their infant's development. Families can participate in the research, even if they chose not to provide contact information." We hope to obtain 50 completed surveys; however, we intend to include all completed surveys if more are obtained from indicated recruitment methods. Upon initial request for participation in the research study, distributed via a survey link in an email or social media, we will accept responses for a 3-week period. All data from completed surveys received during this time will be prepared and analyzed for research purposes.

You are granted permission to conduct your study as revised effective immediately. This study is not subject to renewal.

Please note that any further changes to the study must be promptly reported and approved.

Contact Tom Bailey (208-828-2179; email humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

November 5, 2020

Heather Ramsdell-Hudock
Speech-Language Pathology
College of Rehabilitation Comm Sciences
MS 8116

RE: Study Number IRB-FY2021-97: Exploration of a Caregiver Report Screening Instrument for Infant Speech Patterns

Dear Dr. Ramsdell-Hudock:

I agree that this study qualifies as exempt from review under the following guideline: Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.
This letter is your approval, please, keep this document in a safe place.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

You are granted permission to conduct your study effective immediately. The study is not subject to renewal.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Acknowledgements Page

I would like to express my heartfelt gratitude to Dr. Heather Ramsdell for allowing me the opportunity to join her in the development of the Speech Sound Development Screener. Working alongside Dr. Ramsdell on this project has been an incredible experience that has enriched my academic and professional journey. Dr. Ramsdell’s guidance was invaluable, her support was unwavering, and her feedback was insightful.

Dr. Ramsdell's expertise and vision have been instrumental in shaping my thesis and the continued development of the screening tool. Her steadfast commitment to excellence has been a source of inspiration throughout the process and enabled me to produce a more robust and comprehensive thesis. I am grateful for her guidance and mentorship, which have enabled me to contribute meaningfully to this project and gain valuable experience in speech-language pathology field. I feel prepared for the challenges and opportunities that lie ahead.

Thank you, Dr. Ramsdell, for allowing me to be part of this incredible journey. Your generosity, support, and guidance have been invaluable, and I am deeply grateful for the opportunity to have worked with you on the Speech Sound Development Screener.

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List of Abbreviations

SSDS ………………………………………………………… *Speech Sound Development Screener*

I/T ……………………………………………………………………………… Infant/toddler

CSBS-DP……………….. *Communication and Symbolic Behavior Scales—Developmental Profile*

SLP ………………………………………………………………….. Speech/language pathology

CV ……………………………………………………………………………. Consonant-vowel

CFA ……………………………………………………………….. Confirmatory factor analyses

ITC ………………………………………………………………………… *Infant–Toddler Checklist*

Facilitating Early Identification through Caregiver Report of Emerging Speech Patterns Using the Speech Sound Development Screener (SSDS)

Thesis Abstract – Idaho State University (2023)

The Speech Sound Development Screener (SSDS) is a new tool to track speech sound development in infants/toddlers through caregiver reports. In this study, 143 families with infants aged between 6 to 18 months participated. The caregivers completed the SSDS, the Communication and Symbolic Behavior Scales—Developmental Profile (CSBS-DP), and a feasibility survey. The results showed an increasing pattern of sound types and tokens with increasing infant age, variation between typically developing infants and those at risk for speech/language delay/disorder, and consistency when compared with the CSBS-DP. The caregiver responses supported the feasibility of the SSDS, indicating it is easy to implement in a home setting without the need for a speech-language pathologist. The findings suggest that the SSDS may be a valid report of developmental status as typical or at-risk, which could have important positive impacts on researchers, clinicians, and clients. However, study limitations and future directions are also discussed.

Key Words: Speech sound development, Screener, Validity, Early intervention, Speech/language delay/disorder, Caregiver report

Introduction

Purpose: We aimed to explore participant responses, validity, and feasibility of a new screening tool, the *Speech Sound Development Screener* (SSDS), created to track infant/toddler (I/T) speech sound development through caregiver reports.

Method: Participants, 143 families with I/Ts between 6 to 18 months of age, were recruited in Pocatello, ID, and surrounding geographical areas. Parents completed informed consent, the SSDS, the Speech Composite of the *Communication and Symbolic Behavior Scales—Developmental Profile* (CSBS-DP; to explore the validity of the SSDS), and a feasibility survey (to probe understanding, ease of completion, and perception of the importance of the SSDS). Descriptive and inferential statistics were calculated across infant age.

Results: From caregiver report on the SSDS, we have found 1) increasing patterns of sound types and tokens to be present with increasing I/T age, 2) variation between typically developing I/Ts and those at risk for speech/language delay/disorder, and 3) consistency with caregiver report on the CSBS-DP Speech Composite. Further, we have also found caregiver responses to support the feasibility of the SSDS.

Conclusions: The results of this research could have several important positive impacts on researchers, clinicians, and clients alike. The screener appears to be easy to implement in a home setting, without the support of a speech-language pathologist, with little extra training or expense to interpret, and the findings may be a valid report of developmental status as typical or at-risk. Clinical implications, study limitations, and future directions are discussed.

Facilitating Early Identification through Caregiver Report of Emerging Speech Patterns Using the Speech Sound Development Screener (SSDS)

During the first few years of life, speech/language development, or lack thereof, sets the stage for communication abilities throughout life (Brady et al., 2004; Bricker et al., 2020; Goldstein et al., 2008; Goode et al., Lang et al., 2019; Lyakso et al., 2014; Määttä et al., 2012; Oller et al., 1999). When caregivers[1] express concerns about late talkers, some adopt a "wait-and-see" attitude when intervention may benefit all concerned. General practitioners and pediatricians often support this wait-and-see attitude by erring on the side of calming anxious parents (Snijder et al., 2022). This cautious approach presents challenges for the early identification of those in need of speech/language intervention (SLP) in the pediatric population. In addition, there are several other reasons for difficulty with the early identification of infants/toddlers (I/Ts) needing SLP. These reasons include, but are not limited to the fact that there is typical developmental variability between I/Ts, a lack of knowledge on language development in parents, and a lack of clear-cut criteria of what would determine if an I/T needs services. Another reason is that there are limited screening procedures that are easy to implement and can flag I/Ts who may need early intervention.

The normative nature of infant vocal productions is demonstrated and defined as a trajectory development and growth curve of accepted milestones (Moore et al., 2018). Results from Moore et al. (2018) showed that a hierarchical relationship exists between the complexity of infant vocal productions and infant age, such that a stage-for-age trajectory of vocal competence for typically developing (including normal hearing) infants under 12 months of age

[1] For the purpose of this research, "caregiver" is defined as any person that is involved in the primary caretaking of the infant.

can be reliably depicted. Several features of typical vocal development are widely recognized as indicators which, for the most part, are independent of the ambient language environment. Such features include steady increases in vocal proficiency (e.g., the transition from quasi vowels to fully resonant nuclei, from marginal to canonical babbling), canonic babble by 10 months of age, and proto-words by 12 months of age (Oller et al., 1999). Canonical syllables are particularly important in development, given that their lack of appearance by 10 months of age can indicate any soft neurological deficits (e.g., subtle deficits in motor coordination, sensory-perceptual difficulties, and involuntary movements that have been linked with poor cognitive development later in childhood; Alamiri et al., 2018). Accordingly, it is important to note that canonical syllables are characterized by fully resonant nuclei, clearly articulated consonants, and timely (acoustic) transitions between the two (Oller, 2000). Further, an infant's proto-words can be defined as the first utterances in which they produce a consistent sequence of sounds (with no phonetic match to the adult target) tied to a consistent referent before idly attempting to speak a language completely.

Caregiver Report

Ramsdell-Hudock et al. (2018) suggested that caregivers can play a critical role in the early identification of children who display atypical infant speech development or those at risk[2] for future speech/language delay/disorder. There is an undeniable bond of understanding between caregivers and their infants, perhaps simply because caregivers are the primary communication partners with their infants. The infant’s immature speech productions are

[2] For this line of research, “at risk” is defined as infants who experienced any of the following conditions prior to 6 months of age: pre- and/or perinatal problems; ear, nose, and throat problems; swallowing/sucking problems; and/or a family history of speech and/or language problems (Brady et al., 2004; Farnsworth, 2019; Goldstein & Schwade, 2008; McDuffie & Yoder, 2010, Ramsdell-Hudock et al., 2018).

recognized uniquely and naturally by their caregivers, one that enables observation of patterns of the gestalt productions, rather than wading through the abundance of sound variations that are observed when listening as a scientist in the research laboratory (Ramsdell-Hudock et al., 2018). Identifying speech sound production outside of this natural context can be challenging because of the variability within and across infants during this developmental timeframe (Fenson et al., 2000). Caregiver perceptions and descriptions of some consonant sounds vary slightly, but the manner and place of consonant production are the same (Moore et al., 2018). A new method is needed to capitalize on the caregiver's unique perspectives and garner a reliable way to report their observations. This is particularly important given the essential role caregivers play in early SLP.

Ramsdell-Hudock et al. (2018) conducted a study to determine if caregivers' reporting of I/T productions would reflect established norms. Children aged 7 to 18 months took part, including 15 caregivers and 15 typically developing infants. For the duration of the longitudinal study, caregivers were interviewed weekly. The interviewers focused on asking the following question: "What sounds/words does your infant make?" (Ramsdell-Hudock et al., 2018, p. 167). The caregiver interviews took approximately 5 minutes to conduct, and responses were phonetically transcribed. Results indicated that the caregiver report replicated established norms and markedness theory, supporting the argument that the caregiver reports are a valuable tool for early identification and clinical application (Ramsdell-Hudock et al., 2018). Finding norms, as well as markedness, is equally important. An indication of markedness in vocal development would be a production that varies from an ordinary or more common form, making it stand out as nontypical or divergent (Reimers, 2015). The findings from Ramsdell-Hudock et al. (2018)

justify incorporating the caregiver reports of early vocalizations into research methods and clinical diagnostic procedures for early identification.

Further, it was suggested that caregiver report is a valuable untapped method for early identification and clinical application. Further support for caregiver report is garnered from the fact that it has been routinely employed reliably with older children starting at around two years of age (Eadie et al., 2010). This line of research was the driving force behind the creation of the SSDS.

Further supporting the validity of caregiver reports, Ramsdell et al. (2012) commented that the caregiver report is more useful than a researcher's transcription of infant vocalizations. A caregiver listens to their infants' vocalizations more naturally than those transcribing the infant's sounds. Caregivers hear all the sounds infants produce, but primarily focus on and report those that are repeated and/or more mature. Because caregivers respond to canonical (more mature) vocalizations with words, the sounds their infants produce are functional, facilitating the acquisition of early phonological skills. The process of phonetic transcription is time-consuming, challenging, and unreliable (the international phonetic alphabet was designed for documentation of mature sounds, which infants lack). As such, transcription results in a detailed picture of an infant's phonetic repertoire with sounds that may or may not be necessary and relevant for word learning (Ramsdell et al., 2012).

The Speech Sound Development Screener (SSDS)

Given the projected importance of caregiver reports of infant vocalizations, the *Speech Sound Development Screener* (SSDS) was created as a caregiver report instrument intended to capture important information about early speech sound milestones. The reason for the development of the SSDS was to incorporate caregiver reports into research methods and clinical diagnostic procedures for earlier identification of children considered at risk for speech sound disorders/delays, use in clinical or home settings with or without professional administration, and to provide more efficient methods of assessment for the speech-language pathologist. Such a tool is critical because it would enable speech-language pathologists to screen more children in a shorter amount of time, which could help to identify more children at risk for later speech or language delays (Swafford, 2021; Thomas, 2020).

The SSDS provides a means for easy identification of the speech sounds I/Ts are producing. Infant speech sound production indicates future language development (Lang et al., 2019; Lyakso et al., 2014; Oller et al., 1999; Sotto et al., 2014). When infants do not begin to produce basic canonical syllables by the age of 10 months, it is a red flag for later speech/language delays and any number of soft neurological deficits, as previously mentioned (Oller et al., 1999). Canonical syllables are the building blocks of words. Furthermore, there is a significant correlation between the type and frequency of vocalizations produced by I/Ts, the number of early words produced, and the development of language skills in preschool (Lyakso et al., 2014; Sotto et al., 2014). We see such reports recurring in the research. However, we have yet to be able to utilize this information efficiently to identify I/Ts in need of speech and language assessments for early intervention.

The SSDS is a screening instrument, which differs from an assessment in that the purpose of a screening instrument is designed to efficiently identify whether a complete speech and language evaluation (including receptive and expressive language, voice, fluency, hearing, etc.) is necessary. The purpose of a full evaluation would be to gain comprehensive knowledge of a client’s speech and language abilities to diagnose and inform intervention (Swafford et al., 2021). The SSDS was developed under the guidance of Dr. Ramsdell in previous thesis work

(Thomas, 2020). In line with its name, the SSDS was developed with the aim of documenting caregiver report of I/T speech sounds. For the SSDS, a bank of questions was generated from caregiver report in prior cross-sectional and longitudinal research conducted in the Infant Vocal Development Laboratory at Idaho State University (e.g., Does your child produce the sound /i/ as in "tea"?; Ramsdell-Hudock et al., 2018). The questions were designed to explore the anticipated differences between I/Ts who are typically developing and those who are at risk. First drafts of the screener were distributed to seven caregivers of infants between the ages of 7 and 18 months and six experts in the field of child phonology (such as speech-language pathologists, child development experts, etc.). These caregivers and experts provided feedback regarding potential revisions and additions to the screener. A revision was made to the screener in order to include more speech sounds based on suggestions.

Within the unpublished thesis by Swafford (2021), a final version of the SSDS was developed, again under the guidance of Dr. Ramsdell. After parent and expert review, adjustments were made, resulting in an SSDS consisting of 133 simple questions, including the identification of 114 possible speech sounds. Corner vowels that had previously been excluded were included, as well as organizing vowels in isolation at the beginning of the screener (Swafford, 2021). Consonant-vowel (CV) syllable structures were expanded to include outside vowels if not previously present. Voiceless stops were added to CV syllable structures (Swafford, 2021). No consonants in isolation were included, as each consonant represented had multiple CV examples (Swafford, 2021). Caregivers would select “yes” or “no” to indicate whether a specific vocal behavior was evident in their I/Ts productions, and caregivers would identify whether each behavior occurred “always, sometimes, or never” (Swafford, 2021).

One purpose of the current project was to determine how caregiver reports on the SSDS vary across I/T age and developmental status. To be useful and pertinent, we wanted to see increasing types and tokens of sounds reported as I/T age increases. We also wanted to see differences in caregiver reports of I/Ts who were typically developing and those who were at risk. Further, we wanted to explore the SSDS by considering its validity and feasibility.

Validity

Validity is used to evaluate the quality of assessments/screeners and indicates the extent to which such tools accurately measure the intended variable. For the purposes of this study, concurrent validity was considered. Concurrent validity measures how well a new test (the SSDS) compares to a well-established test (the *Communication and Symbolic Behavior Scales—Developmental Profile*, CSBS-DP). The CSBS-DP is a standardized, normed assessment that measures seven key language predictors: emotion and eye gaze, communication, gestures, sounds, words, understanding, and object use. Often, the first sign of developmental delays is in social communication, expressive speech/language, and symbolic functioning (Wetherby et al., 2002). Based on both parent reports and face-to-face evaluations with children, a total of 45 questions on the CSBS-DP assessment provide results in the seven language areas (Wetherby et al., 2002).

The CSBS-DP contains three formal tests: the CSBS Caregiver Questionnaire, the CSBS Behavior Sample (BS), and the Caregiver Perception Rating form. For the CSBS-DP, six aspects of validity were assessed during its development: face, content, criterion, construct (Limosani et al., 2020; Wetherby et al., 2005), predictive, and concurrent validity (Eadie et al., 2010). The face validity of a test is the extent to which it appears to measure the concept it is supposed to measure. For example, if researchers aim for an assessment to document the types of sounds a particular child is producing, the questions on the assessment should encompass the speech productions expected of a child to ensure face validity. The CSBS-DP was determined to have strong face validity (Limosani et al., 2020; Wetherby et al., 2002). Generally, content validity refers to the degree to which a measure is representative of all facets of a given construct. For example, a number of studies have been conducted to examine the degree of relationship between one construct and another construct (Eadie et al., 2010; Limosani et al., 2020; Wetherby et al., 2005). The correlation between the two constructs represents the degree to which the first construct predicts the second construct. The CSBS-DP assessment measures seven key language areas and has been deemed to demonstrate strong content validity (Limosani et al., 2020; Wetherby et al., 2002). The criterion validity of a measure refers to its ability to predict the outcome of another related measure. The evaluation of criterion validity for the CSBS-DP demonstrated strength in comparison between scores of child language abilities across a 4-month interval (Limosani et al., 2020; Wetherby et al., 2002).

The measure of construct validity can be viewed as the accumulation of evidence that supports an interpretation of what the assessment represents. The construct validity of the CSBS-DP is of particular interest to the purpose of the present study, that is, how well the items within each composite score on the CSBS-DP relate to one another, and to the underlying theory of the assessment (Wetherby et al., 2002). Researchers used confirmatory factor analyses (CFA) to examine the structure of the CSBS-DP (Wetherby et al., 2002). Confirmatory factor analysis allows for the exploration of correlational relationship between a number of variables that are said to measure a particular construct, and can therefore verify that construct measures match the researcher's understanding of the construct. The CSBS-DP demonstrated good construct validity through the appropriateness of scores on the assessment (Wetherby et al., 2002). When comparing scores from the CSBS-DP BS to those from the *Infant–Toddler Checklist* (ITC) it was concluded that the CSBS-DP is a clinically valid tool for measuring constructs broadly representing social, speech, and symbolic communication skills (Wetherby et al., 2002). The speech composite, in particular the sounds subscale, emerged with strong validity under the CSBS-DP for this age group. We plan to compare the speech composite of the CSBS-DP to caregiver reports of I/T speech sound productions on the SSDS.

The predictive and concurrent validity of the CSBS-DP were also observed by Eadie et al. (2010). The term predictive validity allows for exploration of whether or not the score on an assessment can be used to predict the value of some future behavior. Research on the CSBS-DP demonstrated good predictive validity for American-English-speaking children from 8 to 24 months and later receptive and expressive language outcomes at 3 years (Eadie et al., 2010; Wetherby et al., 2002).

Checking how well caregiver reports on the SSDS correspond with caregiver responses on the established and normed CSBS-DP speech composite, will establish how the SSDS is measuring similar concepts. Having a good to strong validity is a vital objective for any new tool because it will increase confidence in the results and support the tool as a useful method of analysis.

Feasibility

Beyond the importance of validity, the feasibility of using caregiver report as a tool for tracking early infant vocal development needs to be considered. Feasibility is defined as the state or degree of being easily or conveniently done. Establishing feasibility is a vital objective for any new tool or method of analysis. Feasibility is a substantial component of wide-scale acceptability for clinicians and parents (Smith et al., 2007). To date, there has not been a widely used, feasible screening tool that takes an in-depth look at over 100 developing sounds to identify I/Ts who may be at risk for a speech/language delay/disorder, and in need of a full evaluation. Such a screener could benefit I/Ts by enabling earlier identification for early intervention. In exploring feasibility, it may be necessary to consider economic feasibility, functional feasibility, and operational feasibility.

Firstly, economic feasibility refers to the ability to achieve the greatest benefit at the lowest cost. For example, several argued cost-benefit advantages of the SSDS include that it is easy to implement clinically and/or in a home setting, with or without the support of a speech-language pathologist, with little extra training or expense to interpret. The argued cost-effectiveness of the SSDS, therefore, is that it does not require infrastructure or highly-qualified professionals to administer, but may still identify both typical developmental patterns and flag those I/Ts who are at risk and need further assessment based on caregiver reports.

Next, functional feasibility allows us to consider whether the SSDS is easy to understand for caregivers, with little guidance from trained professionals. Because it is the caregiver that is filling out the SSDS, numerous professionals can initiate this screener (e.g., developmentalists, pediatricians, daycare/preschool teachers, speech-language pathologists, etc.), but it would be possible for caregivers to complete the screener independently, without guidance from professionals if they are able to understand the questions.

Lastly, operational feasibility allows us to consider adapting this screener to family or community settings and to gather the data needed to measure the benchmarks of speech sound development to facilitate more accurate recommendations for further assessments and identification of those who appear to be at risk. Caregiver reports can be gathered in a timelier manner than recordings and phonetic transcriptions of infant vocalizations (Ramsdell-Hudock et al., 2018). There is flexibility for the administration of this screener to reach a varied participant population and allow further developmental measures to monitor progress as the I/T grows. The operational feasibility of the SSDS will allow it to be more readily used by professionals working with young children.

Identifying I/Ts that need early SLP is a pressing matter throughout the nation. We need a feasible tool for such identification because of the critical nature of this period of prelinguistic development, during which I/Ts are exploring the capacity of the speech production mechanism (in terms of extremes between whispers and yells for amplitude, squeals and growls for frequency, etc.), but not yet actively producing true words (Brinkly et al., 2020; Yoder et al., 2014). Creating a feasible tool/screener of I/T speech sound development during this critical period, a tool that utilizes caregiver reports, will be beneficial for I/Ts and their families. Caregivers, after all, may be able to provide us with expert insight into the phonetic and phonological repertoires of their I/Ts (Ramsdell et al., 2012; Ramsdell-Hudock et al., 2018), but only if the tool used to gather caregiver report is feasible.

Early Intervention Need

The cost of *not* identifying I/Ts with early intervention needs is financially and educationally adverse for future outcomes. There is considerable evidence in decades of research that demonstrates experiences during the first years of a child's life play an important role in brain development (see for detail Goode et al., 2020). The growing brain is most flexible and responsive during the first 3 years of life (Bricker et al., 2020; Duncan et al., 2017; Goode et al., 2020; Iyer et al., 2016; Johnson et al., 2008; Määttä, 2012; McLean et al., 1997; Rosenberg et al., 2008; Temple et al., 2015). During this time, neural circuits are created that serve as the basis for learning and behavior. Changing these pathways and circuits becomes increasingly challenging with age, as patterns become established and more solidified (Bricker et al., 2020; Duncan et al., 2017; Goode et al., 2020; Iyer et al., 2016; Johnson et al., 2008; Määttä, 2012; McLean et al., 1997; Temple et al., 2015). Accordingly, the principles of neuroscience suggest that early preventive intervention is more efficient, and produces more favorable outcomes than remediation later in life (Goode et al., 2020; Määttä, 2012; McLean et al., 1997). For the brain to flourish, it requires a range of positive early experiences, such as stable relationships with nurturing adults, safe environments, supportive caregivers, and good nutrition (Bricker et al., 2020; Goode et al., 2020).

In order to prepare I/Ts for success in school and later in life, positive early development of emotional, social, cognitive, and language capacities are necessary (Bricker et al., 2020; Duncan et al., 2017; Goode et al., 2020; Iyer et al., 2016; Johnson et al., 2008; Määttä, 2012; McLean et al., 1997; Temple et al., 2015). Early social/emotional development and physical health provide the foundation upon which cognitive and language skills develop (Gennetian et al., 2020; Goode et al., 2020). Quality early intervention services can have a profound impact on a child's developmental trajectory, improving outcomes for children, families, and communities (Bricker et al., 2020; Duncan et al., 2017; Gennetian et al., 2020; Goode et al., 2020; Iyer et al., 2016; Johnson et al., 2008; Määttä, 2012; McLean et al., 1997; Rosenberg et al., 2008; Temple et al., 2015). Intervention is likely to be more effective and less costly when provided earlier in life rather than later, or at the very least, early intervention will lessen the quantity of intervention needed later (Duncan et al., 2017; Gennetian et al., 2020; Goode et al., 2020; Temple et al., 2015). For every $1.00 spent on early intervention for a child in need, the school system can expect to save $2.88 later on special education services provided in the schools (Temple et al., 2015). In addition to reducing the financial burden of special education, there are other benefits to society (Duncan et al., 2017; Gennetian et al., 2020; Goode et al., 2020; Rosenberg et al., 2008; Temple et al., 2015).

More I/Ts need early intervention than are currently being served. It has been reported that 2.67% of the general population of I/Ts aged birth to 3 years are receiving early intervention services (Rosenberg et al., 2008). However, research indicates that as many as 13% of birth to 3-year-olds have delays that would make them eligible for services (Rosenberg et al., 2008). Language/speech delays or disorders are frequently identified between 2 and 3 years of age (Eadie et al., 2010; Sachse et al., 2008; Bricker et al., 2020). There is a need to serve more I/Ts earlier. Research has shown that at 9 months of age, only 9% of children who have delays receive early intervention services and that at 24 months of age, only 12% of eligible children receive services (Goode et al., 2020). There are several reasons why I/Ts may not be identified as having a speech/language delay, including: developmental variability within and between I/Ts, lack of awareness from caregivers, and the adoption of an “wait and see” attitude from healthcare professionals (Fenson et al., 2000, Snijder et al., 2022). Caregivers will often look to their healthcare professionals to guide them on if their I/Ts are meeting typical milestones and may not realize that their child is falling behind. The "wait and see" attitude is a common approach used by many healthcare professionals when assessing children's speech and language development. This approach involves observing the child's development over time, without immediately recommending any intervention. The article by Snijder et al. (2022) discusses the results of a study on the effectiveness of this approach in identifying language delays in young children. The study found that a wait and see approach was less effective in identifying language delays compared to a proactive screening approach. The researchers suggested that the wait and see approach may result in delays in receiving appropriate interventions and support, which can have negative effects on a child's language development and academic performance. They suggested that healthcare professionals should use a more proactive approach to screening and identifying language delays in young children (Snijder et al., 2022).

During the period between 8 and 24 months, the development of gestures, early vocalizations, and symbolic play are essential for the emergence of communication. (Eadie et al., 2009). Despite this, the identification of early communication delay is difficult because of the lack of reliable indicators (Reilly et al., 2007), significant individual variation in development, and problems inherent in assessing very young infants and toddlers (Sachse et al., 2008). Parent reports should be one strategy used as an instrument for both screenings and supporting a diagnosis of communication delay (Eadie et al., 2009).

Purpose

Accordingly, through the use of the newly created SSDS, we asked caregiver participants to report speech sounds they perceived their I/Ts capable of producing. We also asked caregivers to respond to questions from the previously normed *Communication and Symbolic Behavior Scales—Developmental Profile* (CSBS-DP) and a brief feasibility survey. Our goals for the proposed study were to:

1. Track I/T speech sound patterns in caregiver reports to consider whether or not the SSDS can accurately differentiate between infants of different ages and developmental status as typically developing or at risk for future speech/language delay/disorder.
2. Compare reports from the SSDS to reports from the CSBS-DP to facilitate the exploration of the validity of the SSDS.
3. Explore responses to the feasibility survey to allow us to probe understanding, ease of completion, and perception of the importance of the SSDS.

The central hypothesis was that the SSDS would accurately, validly, and feasibly track speech sound development and identify infants at risk for speech/language delay/disorder. The rationale for the project was that there is a need for earlier identification of speech/language delay/disorder. The project provides validity and feasibility for earlier identification through caregiver report on the SSDS.

The specific scope of this project was to demonstrate patterns in I/T speech sound production based on caregiver reports, allowing us to validly and feasibly differentiate between infant age and developmental status as typically developing or at risk for future speech/language delay/disorder. The SSDS was designed to guide caregivers through the process of tracking their I/T's speech/language development efficiently and effectively, through a manner that is easy to implement clinically and/or in a home setting with and/or without the support of a speech-language pathologist, and with little extra training or expense to interpret. Eventually, the goal would be for infants flagged as at-risk through caregiver responses on the SSDS to be referred for a complete speech and language evaluation, thus facilitating early identification. Accordingly, the SSDS will initiate the pathway to early intervention services at an earlier age than is now common.

- ***Aim #1:*** Caregivers reported the speech sound productions of their infants/toddlers from 6 to 18 months of age using the SSDS. The caregiver report was used to track speech sound patterns in development. As reported by caregivers, a determination of the relationship between the type and token of vocalizations produced can be used as a baseline for referral for further assessment from a certified speech-language pathologist.
- ***Working hypothesis for Aim #1***: We expected caregiver reports of younger infants to consist of fewer types/tokens in comparison to older toddlers, and an apparent

developmental growth across age to be observable. Further, we expected infants at risk to be reported to produce fewer vocal features than those typically developing. Caregiver reports are a vital portion of the process of tracking the development and identifying atypical patterns because of the bond and relationship between the caregiver and the infant.

- ***Aim #2:*** Caregivers completed the *Speech Composite* questions on the CSBS-DP. Comparing the report from the SSDS to the report from the CSBS-DP facilitated the exploration of the validity of the SSDS.
- ***Working hypothesis for Aim #2:*** We expected that CSBS-DP, which is a standardized assessment, would have the same, or comparable results to the SSDS across infant age and developmental status as typically developing or at risk, which would validate the new tool.
- ***Aim #3:*** Caregivers responded to three questions related to the feasibility of the SSDS. Exploring responses to the feasibility survey allowed us to probe understanding, ease of completion, and perception of the importance of the SSDS.
- ***Working hypothesis for Aim #3:*** We expected caregivers to report that they largely understood questions on the SSDS, found the screener easy to complete, and supported the importance of the tool as a means for identifying atypical patterns in development.

Methods

Research packets, including informed consent (approved by the Human Subjects Committee at Idaho State University), the SSDS, the CSBS-DP, the feasibility questions, and an addressed and stamped return envelope, were distributed to approximately 300 families of infants from 6 to 18 months of age in Pocatello, ID, and the surrounding areas. The number of families who received a research packet was simply an estimate of how many families we thought we could access in a set amount of time, as opposed to a systematically chosen number based on power analysis. Caregivers were asked to fill out and mail back all forms in the packet. Caregiver responses were entered into an electronic database for pattern analysis. We tracked developmental patterns to identify differences across infant age and developmental status as typical or at risk. Further, results from the SSDS and CSBS-DP were compared to determine if the SSDS is as valid at identifying children who are at risk of later delays/disorders.

Descriptive statistics (frequencies, percentages, mean, and range) were calculated to describe demographics and response rates. Comparisons were made across infant age, between responses to the SSDS and CSBS-DP, and on feasibility information. Inferential statistics were calculated using Jamovi, an open statistical software package. *T*-tests were used to explore caregiver report of I/T sounds produced across age, and chi-square was used to explore caregiver report across the SSDS and CSBS-DP. For the purpose of this study, a significance level (p) was set at 0.01.

Results

The method of convenience sampling was utilized to distribute 300 surveys through five distinct channels in and around Pocatello, ID: family members and acquaintances of the primary investigator, participants in parenting classes (sponsored by Madison Cares), contacts on parenting social media (Facebook groups e.g. "American Mothers Inc." and "Rexburg Moms Supporting Moms") , and face-to-face contacts within the community (e.g. church organizations, community parks, and play groups). From the 300 distributed surveys, 143 responses were returned (100% of which were useable for analysis, with some intermittent blank responses to questions and some infant ages outside of the 6-to-18-month age range); a 47.67% response rate.

All analyzed data came from individuals who provided informed consent and permission to use their responses for research purposes (with the exception 2 families who did not respond in the affirmative or negative with respect to informed consent; yet responded to the entirety of the survey).

Demographics

Of the 143 participant responses explored, 58 of the infants were female and 85 of the infants were male. While it was requested that families with infants between 6 and 18 months complete the survey, we did have some families with both older and younger infants respond. Accordingly, there is one 2-month-old male, one 5-month-old female, and one 20-month-old male in the dataset. When asked if parents were concerned about their child's speech and language development, 20 participants responded "yes" (13.98%), 98 responded "no" (68.53%), and 25 did not respond (17.48%). Of the parents concerned, 11 of the infants were female and 9 were male, with the range of ages from 6 to 18 months represented (average age of 13 months).

Aim 1

Recall that Aim 1 was to gather caregiver report of I/T speech sound productions using the SSDS; to track speech sound patterns in development. Table 1a presents the descriptive and inferential statistics for three sounds reported by caregivers on the SSDS, with all sounds presented in Table 1b of the Appendix. The data was split for reporting purposes due to the large number of sounds/sound combinations explored, and resulting length of the table with all sounds/sound combinations included. Accordingly, given that 110 different sounds/sound combinations were explored, we will report narrative data for only the three speech sounds/sound combinations in Table 1a to exemplify common patterns observed in all of the data (see Table 1b). First, there was a statistically significant difference in chronological age between those who were reported to, versus *not* reported to make the /ɑ/ sound (as in "top"; $p = 0.006$). The mean age of the children who were reported to produce the /ɑ/ sound was 12.7 months (*SD* = 3.89), while the mean age of children who were *not* reported to produce the /ɑ/ sound was 10.7 months (*SD* = 4.14). Second, there was a statistically significant difference in chronological age between those who were reported to, versus *not* reported to make the /mɑ/ sound (as in "mom"; $p < 0.001$). The mean age of the children who were reported to produce the /mɑ/ sound combination was 12.8 months (*SD* = 3.88), while the mean age of children who were *not* reported to produce the /mɑ/ sound combination was 9.54 months (*SD* = 3.62). Third, there was a statistically significant difference in chronological age between those who were reported to, versus *not* reported to make the /dɑ/ sound (as in "dog"; $p < 0.001$). The mean age of the children who were reported to produce the /dɑ/ sound combination was 14.2 months (*SD* = 3.39), while the mean age of children who were *not* reported to produce the /dɑ/ sound combination was 9.96 months (*SD* = 3.61).

Table 1a

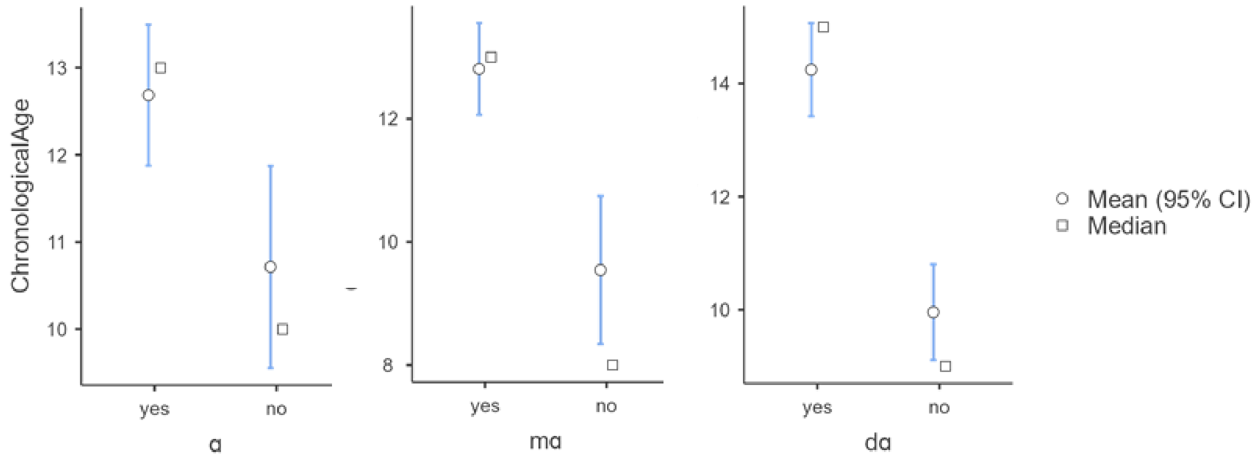
Descriptive and Inferential Statistics for /a/, /ma/, and /da/ as Reported by Caregivers on the Speech Sound Development Screener *(SSDS)*

Speech Sound	SSDS Prompt	Yes		No		*df*	*t*	*p*
		Mean	*SD*	Mean	*SD*			
ɑ	"**to**p"	12.7	3.89	10.7	4.14	136	2.78	0.006
mɑ	"**mo**m"	12.8	3.88	9.54	3.62	137	4.48	<0.001
dɑ	"**do**g"	14.2	3.39	9.96	3.61	133	7.11	<0.001

The differences in mean ages for production of /ɑ/, /mɑ/, and /dɑ/ across caregiver report on the SSDS are also depicted in Figure 1. The lack of overlap in the blue confidence interval bars on Figure 1 highlights the significant differences observed between I/Ts who were reported to, versus were *not* reported to produce /ɑ/, /mɑ/, and /dɑ/ by caregivers. Further, Figure 2 shows the percent of infants (across infant age) who were reported to produce /ɑ/ by caregivers on the SSDS. Observation of the red trend line in Figure 2 clearly illustrates the influence age has on caregiver report, with more caregivers reporting that their I/Ts are producing /ɑ/ with increasing infant age. Figures 1 and 2 are representative of all statistically significant results across the dataset.

Figure 1

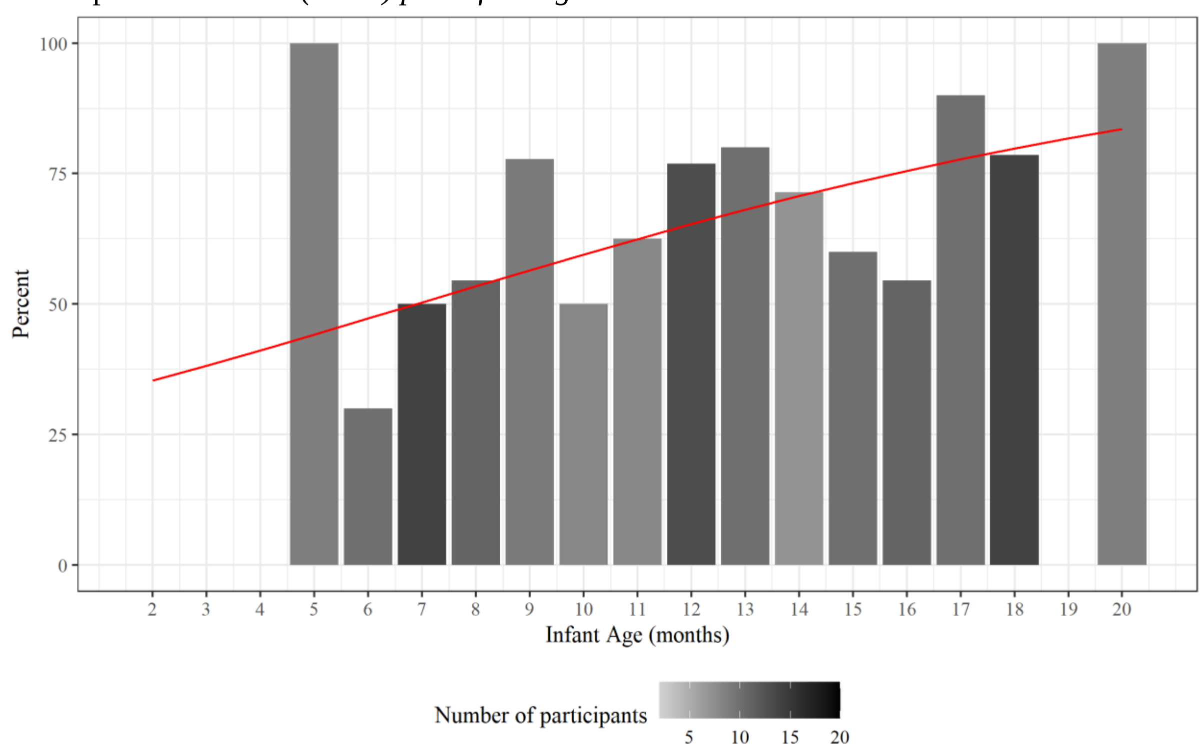
Mean Infant Age (in Months) of Production for /a/, /ma/, and /da/ as Reported by Caregivers on the Speech Sound Development Screener *(SSDS)*



Note. "Yes" indicates that caregivers responded their infant/toddler *could* produce the sound, and "no" indicates that caregivers responded their infant/toddler *could not* produce the sound.

Figure 2

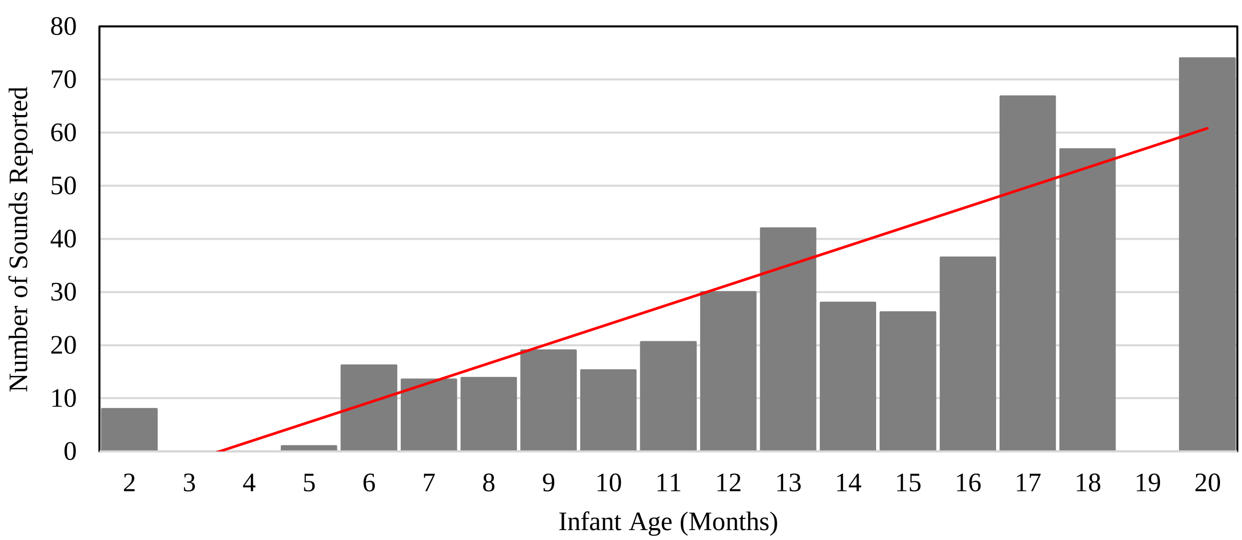
Percent of Infants who were Reported to Produce /a/ by Caregivers on the Speech Sound Development Screener *(SSDS) per Infant Age*



The majority of the 110 comparisons across age for speech sounds explored were statistically significant at the level of $p \leq 0.01$ with the exception of /ʌ/ (as in "tub"; $p = 0.015$),

/ɛ/ (as in “ten”; *p* = 0.014), /mʌ/ (as in “mud”; *p* = 0.019), /wʌ/ (as in “what”; *p* = 0.017), /hʌ/ (as in “hut”; *p* = 0.012), /gʌ/ (as in “gum”; *p* = 0.379), /gɑ/ (as in “got”; *p* = 0.071), /gu/ (as in “goop”; *p* = 0.021), /vi/ (as in “veal”; *p* = 0.025), /vɑ/ (as in “volley”; *p* = 0.203), /ʤʌ/ (as in “jug”; *p* = 0.215), /θi/ (as in “theme”; *p* = 0.013), /θɑ/ (as in “thaw”; *p* = 0.189), and /li/ (as in “leap”; *p* = 0.015). Figure 3 shows the average number of sounds infants were reported to produce by caregivers on the SSDS per infant age. Unlike Figures 1 and 2, Figure 3 is a summary of *all* 110 sound/sound combination options available for caregivers to report on the SSDS, rather than simply three sound/sound combinations (Figure 1) or one sound (Figure 2). Observation of the red trend line in Figure 3 again clearly illustrates the influence age has on caregiver report, with caregivers reporting that their I/Ts are producing more sounds/sound combinations with increasing infant age.

Figure 3
Average Number of Sounds Infants were Reported to Produce by Caregivers on the Speech Sound Development Screener *(SSDS) per Infant Age*



Finally, as shown in Table 2, at many infant ages there was a statistically significant difference in the number of sounds caregivers reported their infants to produce dependent upon whether or not they were concerned about their infant's development. In Table 2, the means represent the number of parents who reported infants to produce the sounds, divided by the total number of infants per age (who parents were or were not concerned about), to normalize for the differing numbers of infants across the different ages. For example, when they were not concerned, parents reported infants to produce 1.827 sounds/sound combinations, on average at 7 months of age (ranging from 0.000 to 0.714 infants producing individual sounds/sound combinations). This number was divided by 14, because there were 14 infants with whom parents were not concerned about, and a mean of 0.131 was obtained. In doing this calculation for all ages, we were able to factor out differing numbers of infants at differing ages, and compare across the ages in a normalized fashion. In every instance, at 6, 7, 11, 14, 15, 17, and 18 months of infant age, infants with whom caregivers WERE NOT concerned were reported to produce more types/tokens of sounds/sound combinations than infants with whom caregivers WERE concerned (who were reported to produce fewer types/tokens of sounds/sound combinations). There was no report of caregiver concern for infants at 9, 12, and 13 months of age in this dataset (so no comparisons made), and there was not a statistically significant difference at $p \leq 0.01$ between those with whom concern was versus was NOT noted at 8, 10 (although this would be statistically significant at $p < 0.05$), and 16 months of infant age.

Table 2

Difference in Caregiver Report of Speech Sounds Produced by Infants who they Were versus Were NOT Concerned About

Infant Age	Caregiver Concern						*df*	*t*	*p*
	Not Concerned			Concerned					
	n	Mean	*SD*	*n*	Mean	*SD*			
6 Months	8	0.163	0.153	2	0.086	0.190	109	4.135	<0.001
7 Months	14	0.131	0.158	1	0.018	0.134	109	6.729	< .001
8 Months	12	0.124	0.158	1	0.136	0.345	109	-0.408	0.684

9 Months	No infants with whom caregivers were concerned.								
10 Months	7	0.127	0.213	2	0.182	0.251	109	-2.163	0.033
11 Months	7	0.164	0.247	1	0.355	0.481	109	-4.456	< .001
12 Months	No infants with whom caregivers were concerned.								
13 Months									
14 Months	4	0.371	0.314	3	0.100	0.228	109	10.553	< .001
15 Months	6	0.265	0.259	4	0.198	0.195	109	3.207	0.002
16 Months	9	0.334	0.273	2	0.318	0.357	109	0.53	0.597
17 Months	9	0.640	0.227	1	0.309	0.464	109	8.209	< .001
18 Months	11	0.566	0.260	3	0.339	0.217	109	10.725	< .001

Note. Comparisons made across 110 sounds/sound combinations reported on by caregivers. Proportion of sounds reported by caregivers across group of infants compared to normalize different infant group sizes.

Aim 2

Recall that Aim 2 was to have caregivers complete the *Speech Composite* questions on the CSBS-DP; to compare report from the SSDS to report from the CSBS-DP for validity. Table 3a presents the descriptive and inferential statistics for comparison of responses across the measurement tools. As with Aim 1, there were many comparisons made to fully explore Aim 2 (57 in total, presented in Table 3b of the Appendix in order of appearance on the CSBS-DP). We will present results for one set of comparisons in the narrative to exemplify the trend in results. There were statistically significant chi square results between caregiver report of I/Ts producing "mommy" on CSBS-DP and caregiver report of I/Ts producing "ma" [$\chi^2(1, N = 139) = 27.3$, $p < 0.001$], "mom" [$\chi^2(1, N = 137) = 44.5$, $p < 0.001$], or "me" [$\chi^2(1, N = 136) = 20.0$, $p < 0.001$] on the SSDS. Of the I/Ts who were reported to/not to produce "mommy" on the CSBS-DP, 69.1% were similarly reported to/not to produce "ma" on the SSDS, 76.6% were similarly reported to/not to produce "mom", and 67.6% were similarly reported to/not to produce "me".

Aim 3

Recall that Aim 3 was to explore the feasibility of the SSDS with respect to caregiver understanding, ease of completion, and perception of importance. Descriptive statistics for feasibility are presented in Table 4. The majority of respondents strongly to somewhat agreed that they were able to understand the questions asked on the SSDS (96.8%). Also, the SSDS (informed consent, CSBS-DP, and feasibility survey) took the majority of respondents under 20 minutes to complete (80.4%). Finally, the majority of respondents strongly to somewhat agreed that the material covered in the SSDS is important (95.8%).

Table 3a

Chi-square between Caregiver Report on the SSDS and CSBS-DP

			CSBS-DP Target: /mɑmi/		
			Yes	No	Total
SSDS Target: /mɑ/	Yes	Observed	65	39	104
		% within column	62.5%	37.5%	100.0%
	No	Observed	4	31	35
		% within column	11.4%	88.6%	100.0%
	Total	Observed	69	70	139
		% within column	49.6%	50.4%	100.0%
χ^2 (1, N = 139) = 27.3, p < 0.001					
SSDS Target: /mɑm/	Yes	Observed	64	28	92
		% within column	69.6%	30.4%	100.0%
	No	Observed	4	41	45
		% within column	8.9%	91.1%	100.0%
	Total	Observed	68	69	137
		% within column	49.6%	50.4%	100.0%
χ^2 (1, N = 137) = 44.5, p < 0.001					
SSDS Target: /mi/	Yes	Observed	31	8	39
		% within column	79.5%	20.5%	100.0%
	No	Observed	36	61	97
		% within column	37.1%	62.9%	100.0%
	Total	Observed	67	69	136
		% within column	49.3%	50.7%	100.0%
χ^2 (1, N = 136) = 20.0, p < 0.001					

Table 4

Descriptive Statistics for Caregiver Understanding, Ease of Completion, and Perception of Importance of the Speech Sound Development Screener *(SSDS)*

		N	%
		Level of agreement	
I was able to understand the questions asked in the SSDS.	Strongly agree	94	65.73%
	Somewhat agree	43	30.07%
	Neither agree nor disagree	2	1.39%
	No response	4	2.79%
		Time in minutes	

Approximately how long did it take for you to complete the SSDS?	Less than 10	65	45.45%
	Between 11 to 20	50	34.97%
	Between 21 to 30	23	16.08%
	More than 31	4	2.79%
	No response	1	0.69%
		Level of agreement	
I think the material covered in the SSDS is important.	Strongly agree	102	71.33%
	Somewhat agree	35	24.48%
	Neither agree nor disagree	5	3.49%
	No response	1	0.69%

Discussion

The purpose of this study was to explore participant responses, validity, and feasibility of a new screening tool, the *Speech Sound Development Screener* (SSDS), created to track infant/toddler (I/T) speech sound development through caregiver report. From caregiver report of I/Ts from 6 to 18 months of age on the SSDS, we expected 1) increasing patterns of sound types and tokens to be present with increasing I/T age, 2) variation between typically developing I/Ts and those who may be at risk for speech/language delay/disorder, and 3) consistency with caregiver report on the CSBS-DP Speech Composite. Further, we expected caregiver responses to support feasibility of the SSDS.

Aim 1. Speech Sound Development and the SSDS

The purpose of Aim 1 was to track speech sound patterns in development across 6 to 18 months of I/T age per caregiver report on the SSDS. The working hypothesis was that younger infants would have fewer types of vocalizations compared to older toddlers, and there would be observable developmental growth across ages. Further, we expected to see differences between infants reported to be typically developing versus those caregivers reported concern for related to their development (i.e., those who may be at risk for future speech/language delay/disorder). Results demonstrated in Tables 1 and 2 and Figures 1, 2, and 3, support these hypotheses, with caregivers reporting I/Ts to produce more vocalizations with increasing infant age, and with differences observed between infants reported as typically developing and those flagged for concern, such that those flagged for concern were reported to produce less variation in reported sounds/sound combinations. Accordingly, the SSDS appears to be demonstrating clear trends in speech sound development with increasing infant age per caregiver report, and simultaneously differentiating between those infants who are typically developing versus those who may be at risk for speech/language delay/disorder.

Out of the 110 speech sounds explored through caregiver report on the SSDS, there were a total of 14 sounds that were consistently reported to be produced (or consistently reported to be *not* produced) across both younger and older I/Ts (in other words, there were no statistically significant differences dependent upon infant age for these sounds/sound combinations at $p < 0.01$). These productions included /ʌ/ (as in "tub"), /ɛ/ (as in "ten"), /mʌ/ (as in "mud"), /wʌ/ (as in "what"), /hʌ/ (as in "hut"), /gʌ/ (as in "gum"), /gɑ/ (as in "got"), /gu/ (as in "goop"), /vi/ (as in "veal"), /vɑ/ (as in "volley"), /ʤʌ/ (as in "jug"), /θi/ (as in "theme"), /θɑ/ (as in "thaw"), and /li/ (as in "leap"). These non-significant results can be easily explained. First of all, regardless of age, the majority of the I/Ts, were reported to produce /ʌ/ (as in "tub"), which is a central vowel. Central vowels are produced with a neutral place of articulation, meaning that the tongue and jaw are not positioned in a specific way (or not positioned in a more pronounced front/back high/low articulation) to produce these vowel sounds. This type of vowel sound is often produced early in language development because it requires less precise articulatory control of the tongue and jaw muscles. Overall, the logic behind central vowels produced with neutral articulatory positioning means that they are easier to produce, making them unmarked and a natural starting point for speech sound development, and providing a logical rationale for most caregivers reporting their infants to produce /ʌ/.

In contrast to the easy-to-articulate neutral vowel that most infants were reported to produce, almost no infants in this sample, again regardless of age, were reported to produce /vi/ (as in "veal"), /vɑ/ (as in "volley"), /ʤʌ/ (as in "jug"), /θi/ (as in "theme"), /θɑ/ (as in "thaw"), and /li/ (as in "leap"). Each of these sound combinations contain consonants considered to be more complex and later to develop than other sounds in the English language.

The consonant /v/ is a voiced labiodental fricative, which requires an elongated squeeze of air to pass the lower lip and upper front teeth. The consonant /ʤ/ is a voiced postalveolar affricate, which is a complex sound that requires precise control of the tongue and jaw muscles. The consonant /θ/ is unvoiced linguadental fricative, which requires a precise configuration of the tongue and teeth to produce the sound. The consonant /l/ is a voiced, alveolar lateral, liquid consonant sound that is produced by curling the tongue and touching the tip of it to the alveolar ridge on the palate. As a result of the required coordination and motor control needed to produce these consonants, they are not typically produced by I/Ts who are still developing the ability to control their speech muscles. Developmentally, these sounds are typically mastered around the age of 4 years or older.

Beyond the sounds that were not statistically significant in this sample because either the majority of infants were (/ʌ/) or were not (/vi/, /vɑ/, /ʤʌ/, /θi/, /θɑ/, and /li/) reported to produce them, there were also several sound combinations with which infants were simply randomly reported to produce across age, with no patterns in development noted. These sound/sound combinations included /ɛ/ (as in "ten"), /mʌ/ (as in "mud"), /wʌ/ (as in "what"), /hʌ/ (as in "hut"), /gʌ/ (as in "gum"), /gɑ/ (as in "got"), and /gu/ (as in "goop"). One possible explanation for the non-significant findings here is that these sounds are developing, but not yet mastered in the I/T age group from 6 to 18 months. That is, some I/Ts produce them, and some do not, such that there were no clear age patterns noted for their mastery in this group of infants.

With respect to whether or not infants were developing typically, specifically as presented in Table 2, there was a statistically significant difference in the number of sounds reported by caregivers who express concern about their infant's development compared to those who do not. Although there were 3 months (ages 8, 10, and 16 months) that were found to be not statistically significant. There are a couple of potential explanations for this difference between the statistically significant and the not statistically significant months. To be thorough, we could postulate that some caregivers could be concerned when no concern is warranted, some caregivers could be unconcerned when concern is warranted, and some caregivers are correctly concerned/unconcerned about their I/T's speech/language development. There are clear instances when the first scenario may be present, such as is the case with caregivers of older children who had a speech/language delay. In this instance, it is not uncommon for caregivers to err on the side of caution and express concerns about their younger I/T's language development. Further, there are always caregivers who will naturally worry about their I/T's development even when there is no need to do so. Ultimately, a full speech and language evaluation of the I/Ts in question would need to be administered to determine whether or not caregiver report of typical/atypical development is in line with I/T true development.

Aim 2. Validity and the SSDS

The purpose of Aim #2 was to explore the validity of the SSDS by comparing caregiver report on this new measure to caregiver report on the CSBS-DP, an established standardized assessment. The working hypothesis was that caregiver report across these measures would be comparable across infant age, which would support validity of the SSDS. Within this study, there were many similarities across caregiver report on the SSDS and the CSBS-DP. These similarities were demonstrated in all 57 sounds/syllables that were compared between the SSDS and the CSBS-DP, with results showing statistically significant similarities between the two tools. Accordingly, we are inclined to suggest that the SSDS is a valid measure of speech sound development; the SSDS is able to accurately assess the same skills and abilities as the established CSBS-DP.

Validating the SSDS is important for several reasons. First, it ensures that the screener is measuring what it is intended to measure. This is important in order to provide accurate and reliable information about an I/T’s speech sound ability. Without validation, it would be difficult to know whether the results of the screener are truly reflective of an I/T’s ability, or if said abilities are influenced by other factors. Second, validation allows for the comparison of results across different groups of children. This can help identify patterns or trends in speech sound development, which can be useful for researchers, clinicians, and educators. Lending additional support to validity of the SSDS, the demographics of 13.98% of caregivers who reported being concerned about their I/T’s speech and language development is comparable to the 13% that Rosenberg et al. (2008) identified in this population. Recall that research indicates that approximately 13% of birth to 3-year-olds have delays that would make them eligible for services, while only 2.67% of the birth to 3-year-old population receives services (Rosenberg et al., 2008). This improves the validity of this study because it can provide insight into the prevalence of speech sounds within the population by having similar demographics of impairment risk to the population as a whole.

Overall, validating the SSDS is crucial for ensuring that it provides accurate and reliable information about an I/T's speech sound ability, and for establishing it as a widely accepted and trusted measure in clinical, developmental, and educational settings.

Aim 3. Feasibility and the SSDS

The purpose of Aim #3 was to explore the feasibility of the SSDS by having caregivers respond to three questions related to their understanding, ease of completion, and perception of the importance of the SSDS. The working hypothesis was that caregivers would report that they largely understood the questions on the SSDS, found the screener easy to complete, and supported the importance of the tool as a means for identifying atypical patterns in development. Within the study, the understanding of the questions and the importance of the material covered was reported as somewhat or strongly agree in more than 95% of respondents. The ease of completion was rated on how long it took to complete the survey and over 80% responded the SSDS took less than 20 minutes to complete. It is important to note that when administered independently (without the CSBS-DP, informed consent, and feasibility questionnaire), the SSDS will require even less time to complete, and therefore further increase ease of completion (if gauged as a measure of time to complete). With the SSDS alone, it is easy to assume the time to complete would be significantly less than the 20 minutes. According to these results, the SSDS is feasible in all three terms of perceived importance, ease of completion, and content understanding.

Study Limitations and Future Directions

There are some potential limitations to consider. The participant selection was convenience sampling and not randomized as it was volunteer based on social media and personal contact outlets. We did ask for sex, age, and whether the caregiver was concerned about their I/Ts speech or language development, but did not have any other demographics on the participants. Being able to analyze further demographics such as socioeconomics, family dynamics, parents' education, and other descriptive characteristics would improve a future study to understand the population more completely. As well as checking that the demographics are truly representative of the population.

It is also not known if the I/Ts who were reported on were typically developing or at risk given that we did not simultaneously conduct a full evaluation of developmental abilities. To control for this limitation in future study of the SSDS, we could conduct both the SSDS and a full speech/language evaluation to allow for cross-reference of I/T developmental status as typically developing or at risk on the screener and per the full evaluation. Further, it would be useful to compare caregiver report on the SSDS to expert report of infant productions. In the future, we could have caregivers complete the SSDS and gather recordings of the infants for researchers/clinical SLPs to analyze. Upon analysis of the recordings, the researchers/clinicians could complete their own SSDS and the results of the two reports (caregiver and researcher/clinician) could be compared to identify whether or not there is overlap/consistency across reports. And finally, caregiver report of infant vocalizations in the research lab has been shown to be related to later vocabulary development (Farnsworth, 2019). This is useful information because it allows researchers and clinicians with a basis for predicting future language skill based on infant vocal production. It would similarly be useful to determine whether or not caregiver report on the SSDS is related to later speech and/or language abilities. Longitudinal study looking at caregiver report on the SSDS and later speech and language abilities in children is therefore a potential goal of future research with this tool.

Future direction for research on establishing the SSDS needs to include establishing a normative standard score for the SDSS to provide a benchmark for comparison with the birth to 3-year-old population. The normative standard score is derived from a representative sample of infants within a particular age range who have undergone the same screener. This sample provides a range of scores that are typical of infants at that age. Therefore, when an infant's score falls outside the range of typical scores, it is an indication that the infant is at risk of developmental delays. Without this normative information, there is not a consistent benchmark to determine which infants are at risk for developmental delays. A normative standard score ensures that all infants receive a fair and accurate evaluation of their communication skills and developmental milestones. Using normative scores, an infant flagged as at risk through caregiver responses to the SSDS could then be referred for a complete speech and language evaluation, thus facilitating early identification.

Clinical Implications and Conclusions

We conclude that the potential of the present findings (paired with continued exploration) support the SSDS as a clinically useful tool that should be able to facilitate earlier identification of children considered at-risk for speech sound disorders/delays, enable use in clinical or home settings with or without professional administration, and support more efficient methods of assessment for speech-language pathologist.

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Appendix A

Idaho State University

Informed Consent

You are being asked to participate in a research study exploring speech development. Your participation in this research is voluntary. If you decide to participate, you are free to withdraw at any time.

We are asking that you complete the following survey (related to your child's development) at some point in the next week. Completion of the survey should take no more than 30 minutes of your time. We will use your responses to explore patterns in development.

There are no risks to participating in this study. We do not know if you will get any benefits by participating. The benefits to you are mostly the same as the benefits to us. You will be helping us learn about development, and this is a contribution to science.

Please note, if you do not want to take part in this study, you do not have to. Anytime that you want to stop participating, that is fine. If you choose to provide your contact information so that we can share screener results, your (your child's) name will not be known and your responses to the study forms will be completely private.

No identifiable information will be documented on survey materials. Survey responses will only be viewed by the researchers conducting the study and laboratory staff, all of whom are trained in human subjects and responsible conduct of research. Results will be maintained indefinitely in the research archives of the project, under the supervision of Heather L. Ramsdell or her successor(s).

If you have any questions about the research study, please contact Heather L. Ramsdell, PhD, CCC-SLP at Idaho State University in the Department of Communication Sciences & Disorders, phone 208-282-3077, email ramsdell@isu.edu. Also, if you have any questions about your rights as a research participant, you may contact the Human Subjects Committee at Idaho State University, phone 208-282-2179.

I agree to complete the following survey. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences. Yes or no

I grant permission for the data generated from this survey to be used in the researcher's publications and presentations on this topic. Yes or no

Contact for Feedback

If you would like to be contacted by one of the researchers after we review your completed survey, please provide your contact information here. Providing contact information is optional and you can participate in the study without providing contact information.

Name: ______________________________

Email: ______________________________

Phone number: ______________________________

Appendix B

Idaho State University

Speech Sound Development Screener

Child's Gender: Child's Birthdate: Today's Date:

Are you concerned about your child's speech and language development? **Yes or no (circle one)**

How often does your child make sounds (throughout the day, in the time that your child is awake, and in the time that you get to spend with your child)? **Always, sometimes, or never (circle one)**

How often (circle one)?	Yes or No (circle one)?	
always, sometimes, never	Yes No	Does your child cry?
always, sometimes, never	Yes No	Does your child laugh?
always, sometimes, never	Yes No	Does your child growl/grunt?
always, sometimes, never	Yes No	Does your child squeal?
always, sometimes, never	Yes No	Does your child produce raspberries (sounds like lip trills or balloons deflating)?
always, sometimes, never	Yes No	Does your child yell?
always, sometimes, never	Yes No	Does your child whisper?
always, sometimes, never	Yes No	Does your child produce sounds while playing by himself/herself?
always, sometimes, never	Yes No	Does your child produce sounds while playing with others (such as parents, siblings, friends, etc.)?
always, sometimes, never	Yes No	Does your child call to you for attention?
always, sometimes, never	Yes No	Does your child imitate speech sounds that you make?
always, sometimes, never	Yes No	Does your child take turns making speech sounds with you or others, as if participating in a conversation?
always, sometimes, never	Yes No	Does your child produce sounds in repetition (such as "ma ma" or "ba ba")?
always, sometimes, never	Yes No	Does your child produce advanced babbling (such as "ma be du yah")?
always, sometimes, never	Yes No	Does your child sometimes sound like they are speaking, but in a different language?
always, sometimes, never	Yes No	Does your child recognize his/her name?
always, sometimes, never	Yes No	Does your child respond to sounds when a source is not visible (perhaps by turning his/her head toward the sound)?
always, sometimes, never	Yes No	Does your child understand simple commands (such as "no" or "sit")?
always, sometimes, never	Yes No	Does your child use baby signs?

On the back page there is a list of speech sounds babies produce in babbling and first words. Indicate whether or not your child produces each sound by circling "yes" or "no". First the sounds have been transcribed using a phonetic alphabet, followed by a description **underlined** in quotation marks. Pay attention to the **underlined** part of the

Appendix C

description only when thinking of the sounds your child makes. Do not worry if your child only produces a few of the speech sounds listed because development of speech sounds is variable across children.

	Yes or No?			Yes or No?			Yes or No?	
/ɑ/ as in "top"	Yes	No	/ʊ/ as in "took"	Yes	No	/ɝ/ as in "turn"	Yes	No
/ʌ/ as in "tub"	Yes	No	/u/ as in "tool"	Yes	No	/eɪ/ as in "tape"	Yes	No
/ɪ/ as in "tip"	Yes	No	/i/ as in "tea"	Yes	No	/aɪ/ as in "tie"	Yes	No
/æ/ as in "tap"	Yes	No	/ɛ/ as in "ten"	Yes	No	/oʊ/ as in "toe"	Yes	No
/pɑ/ as in "pa pa"	Yes	No	/pi/ as in "peas"	Yes	No	/pu/ as in "pool"	Yes	No
/pʌ/ as in "putt"	Yes	No	/pæ/ as in "pass"	Yes	No	/pɪ/ as in "pin"	Yes	No
/bɑ/ as in "ball"	Yes	No	/bi/ as in "be"	Yes	No	/bu/ as in "boo"	Yes	No
/bʌ/ as in "bud"	Yes	No	/bæ/ as in "bat"	Yes	No	/bɪ/ as in "bid"	Yes	No
/dɑ/ as in "dog"	Yes	No	/di/ as in "deep"	Yes	No	/du/ as in "do"	Yes	No
/dʌ/ as in "done"	Yes	No	/dæ/ as in "dad"	Yes	No	/dɪ/ as in "dip"	Yes	No
/mɑ/ as in "mom"	Yes	No	/mi/ as in "me"	Yes	No	/mu/ as in "moo"	Yes	No
/mʌ/ as in "mud"	Yes	No	/mæ/ as in "mat"	Yes	No	/mɪ/ as in "mit"	Yes	No
/nɑ/ as in "not"	Yes	No	/ni/ as in "knee"	Yes	No	/nu/ as in "new"	Yes	No
/nʌ/ as in "nut"	Yes	No	/næ/ as in "nap"	Yes	No	/nɪ/ as in "knit"	Yes	No
/jɑ/ as in "yawn"	Yes	No	/ji/ as in "year"	Yes	No	/ju/ as in "you"	Yes	No
/jʌ/ as in "yum"	Yes	No	/jæ/ as in "yeah"	Yes	No	/jɪ/ as in "yippy"	Yes	No
/wɑ/ as in "watt"	Yes	No	/wi/ as in "week"	Yes	No	/wu/ as in "woo hoo"	Yes	No
/wʌ/ as in "what"	Yes	No	/wæ/ as in "wagon"	Yes	No	/wɪ/ as in "wind"	Yes	No
/hɑ/ as in "hot"	Yes	No	/hi/ as in "he"	Yes	No	/hu/ as in "who"	Yes	No
/hʌ/ as in "hut"	Yes	No	/hæ/ as in "hat"	Yes	No	/hɪ/ as in "hit"	Yes	No
/tɑ/ as in "top"	Yes	No	/ti/ as in "tea"	Yes	No	/tu/ as in "two"	Yes	No
/tʌ/ as in "tub"	Yes	No	/kɑ/ as in "cop"	Yes	No	/ki/ as in "key"	Yes	No
/ku/ as in "cool"	Yes	No	/kʌ/ as in "cut"	Yes	No	/gɑ/ as in "got"	Yes	No
/gi/ as in "geek"	Yes	No	/gu/ as in "goop"	Yes	No	/gʌ/ as in "gum"	Yes	No
/fɑ/ as in "fog"	Yes	No	/fi/ as in "feet"	Yes	No	/fu/ as in "food"	Yes	No
/fʌ/ as in "fun"	Yes	No	/vɑ/ as in "volley"	Yes	No	/vi/ as in "veal"	Yes	No
/vu/ as in "voodoo"	Yes	No	/tʃɑ/ as in "chalk"	Yes	No	/tʃi/ as in "cheek"	Yes	No
/tʃu/ as in "chew"	Yes	No	/tʃʌ/ as in "chug"	Yes	No	/dʒɑ/ as in "job"	Yes	No
/dʒi/ as in "jeep"	Yes	No	/dʒu/ as in "juice"	Yes	No	/dʒʌ/ as in "jug"	Yes	No
/θɑ/ as in "thaw"	Yes	No	/θi/ as in "theme"	Yes	No	/ði/ as in "these"	Yes	No
/sɑ/ as in "saw"	Yes	No	/si/ as in "see"	Yes	No	/su/ as in "soup"	Yes	No
/zi/ as in "zebra"	Yes	No	/zu/ as in "zoo"	Yes	No	/θðʃɑ/ as in "job"	Yes	No
/dʒi/ as in "jeep"	Yes	No	/dʒu/ as in "juice"	Yes	No	/rɑ/ as in "rock"	Yes	No
/ri/ as in "reach"	Yes	No	/ru/ as in "room"	Yes	No	/lɑ/ as in "lock"	Yes	No
/li/ as in "leap"	Yes	No	/lu/ as in "loop"	Yes	No	/ʌm/ as in "um"	Yes	No
/ʌʔoʊ/ as in "uh oh"	Yes	No	/bɑɪ/ as in "bye"	Yes	No	/mɑm/ as in "mom"	Yes	No
/hʌp/ as in "hup" like "cup"	Yes	No	/heɪ/ as in "hey"	Yes	No	/haɪ/ as in "hi"	Yes	No
/ʘ/ a "kissy" noise	Yes	No	/ǁ/ a tongue "click"	Yes	No	OTHER:	Yes	No

References:

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Ramsdell-Hudock, H.L., Stuart, A., & Peterson, T. (2018). What do caregivers tell us about infant babbling? *Studies in Linguistics and Literature. 2*(3). Retrieved from www.scholink.org/ojs/index.php/sll

Farnsworth, A., & Ramsdell-Hudock, H.L. (2019, November). Examining caregiver report of infant vocalizations and later vocabulary ability. Poster presented at the American Speech-Language-Hearing Association Annual Convention, Orlando, FL.

Appendix D

Idaho State University

Feasibility of the Speech Sound Development Screener

Approximately how long did it take for you to complete the Speech Sound Development Screener?

- Less than 10 minutes
- 11 to 20 minutes
- 21 to 30 minutes
- More than 31 minutes

Please indicate your level of agreement with the statement: I was able to understand the questions asked in the Speech Sound Development Screener.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Please indicate your level of agreement with the statement: I think the material covered in the Speech Sound Development Screener is important.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Appendix E

CSBS DP

CSBS DP Caregiver Questionnaire

Child's name: ______ *Date of birth:* ______ *Date filled out:* ______

Was birth premature? ______ *If yes, how many weeks premature?* ______

Filled out by: ______ *Relationship to child:* ______

Instructions for caregivers: The following questions are about how your child communicates and plays. The questions have to do with how your child expresses him- or herself using actions, gestures, sounds, or words. We would like you to fill this out over a weekend or at a time when you can observe your child and notice the behaviors listed. Please check all the choices that best describe your child's behavior. If you are not sure, please choose the closest response based on your experience. **Children at your child's age are not necessarily expected to be able to do all the behaviors listed.**

Please complete only questions 21-28.

Emotion and Eye Gaze

1. When your child is happy, does he/she smile or laugh and look at you at the same time?	☐ Not yet	☐ Sometimes	☐ Often
2. When your child is playing with a toy, does he/she look at you and then back at the toy?	☐ Not yet	☐ Sometimes	☐ Often
3. If you look at and point to a toy out of your child's reach, does your child look at the toy?	☐ Not yet	☐ Sometimes	☐ Often
4. When your child is upset or frustrated, does he/she express this clearly with facial expression, sounds, or words?	☐ Not yet	☐ Sometimes	☐ Often
5. How often does your child get upset or f	☐ Rarely	☐ Sometimes	☐ Often
6. When your child is upset, does he/she cal	Rarely	☐ Sometimes	☐ Usually
7. When you are with your child, is your ch unfamiliar people or new situations?	Rarely	☐ Sometimes	☐ Usually
8. When your child is afraid, does he/she s	Not yet	☐ Sometimes	☐ Often

Communication

9. Does your child clearly let you know wh (for example, wants you to open a cont	Not yet	☐ Sometimes	☐ Often
10. Does your child clearly let you know wh that is out of reach?	Not yet	☐ Sometimes	☐ Often
11. Does your child let you know that he/she does not want something that you are offering him/her?	☐ Not yet	☐ Sometimes	☐ Often
12. Does your child greet you when you come in the room or leave?	☐ Not yet	☐ Sometimes	☐ Often
13. Does your child reach out to give you a hug or kiss?	☐ Not yet	☐ Sometimes	☐ Often
14. Does your child try to get your attention when you are busy doing something, such as when you are talking with an adult or preparing a meal?	☐ Not yet	☐ Sometimes	☐ Often
15. If your child does something that is funny and you laugh, does your child do it again for the attention?	☐ Not yet	☐ Sometimes	☐ Often
16. Does your child try to get you to notice interesting objects, not to get you to do anything with them, but just to get you to look at them (for example, show you an object or point to a picture in a book)?	☐ Not yet	☐ Sometimes	☐ Often
17. Does your child try to draw your attention to exciting or unexpected things, such as a pop-up toy or something falling down?	☐ Not yet	☐ Sometimes	☐ Often
18. If you can't figure out what your child is trying to communicate, does your child try again or use a different way to get his/her meaning across?	☐ Not yet	☐ Sometimes	☐ Often

Gestures

19. Does your child use gestures that are easily understood by others, such as giving objects, showing objects, pointing, and waving? ☐ Not yet ☐ Sometimes ☐ Often

20. Which of the following gestures have you seen your child use?

- ☐ give an object to you
- ☐ show an object to you (i.e., by extending arm but not releasing object)
- ☐ push an object away
- ☐ raise arms to be picked up
- ☐ reach with an open hand toward an object
- ☐ wave "hi" or "bye bye"
- ☐ point to an object or a picture that is within reach
- ☐ point to an object or a picture out of reach
- ☐ shake head to indicate "no"
- ☐ nod head to indicate "yes"

Sounds

21. Does your child use sounds to communicate both pleasure and discomfort? ☐ Not yet ☐ Sometimes ☐ Often

22. Children use sounds to communicate in vocal play before they use sounds in words. Does your child use a variety of different consonant sounds, such as "ba," "ga," "ta," and "da," either in vocal play or in words? ☐ Not yet ☐ Sometimes ☐ Often

23. If so, which of the following sounds have you heard your child use, either in vocal play or in words?

- ☐ /m/ as in "mamamama" or "mama" or "moo"
- ☐ /n/ as in "nununu" or "no no"
- ☐ /b/ as in "babababa" or "bibo" or "boo" or "bye bye"
- ☐ /d/ as in "dodododo" or "daddy"
- ☐ /g/ as in "googoo" or "gone gone"
- ☐ /w/ as in "woowoo" or "weewee" or "wagon"
- ☐ /l/ as in "lalala" or "balloon" or little"
- ☐ /y/ as in "yayaya" or "yum yum" or "you"
- ☐ /s/ as in "sasasa" or "sock" or "kiss"
- ☐ /sh/ as in "shashasha" or "hush" or "shoe"

24. Does your child put sounds together, either in vocal play or words (for example, "baba," "mamama," "dada," "bye bye")? ☐ Not yet ☐ Sometimes ☐ Often

Words

25. Does your child use words to communicate that are understandable to you? ☐ Not yet ☐ Sometimes ☐ Often

26. If so, which of the following words have you heard your child use (include approximations that you recognize, such as "nana" for banana or "baba" for bottle)?

☐ mommy	☐ moo	☐ night night	☐ bath	☐ Others (optional):
☐ daddy	☐ woof	☐ outside	☐ book	
☐ baby	☐ grr (animal noise)	☐ yum yum	☐ car	
☐ dog	☐ peekaboo	☐ vroom	☐ cookie	
☐ kitty	☐ bye bye	☐ ouch	☐ juice	
☐ bird	☐ no	☐ up	☐ sock	
☐ duck	☐ hi	☐ bottle	☐ keys	
☐ eye	☐ all gone	☐ banana	☐ balloon	
☐ nose	☐ uh oh	☐ ball	☐ truck	

27. Does your child use words that are understandable to unfamiliar adults? ☐ Not yet ☐ Sometimes ☐ Often

28. Does your child put two or more words together (for example, more cookie, daddy car, bye bye kitty)? ☐ Not yet ☐ Sometimes ☐ Often

Appendix F

Table 1b

Descriptive and Inferential Statistics for Sound/Sound Combinations Reported by Caregivers on the Speech Sound Development Screener (SSDS)

Speech Sound	SSDS Prompt	Yes		No		*df*	*t*	*p*
		Mean	*SD*	Mean	*SD*			
i	"t**ea**"	13.2	3.88	10.9	3.92	136	3.45	<0.001
ɪ	"t**i**p"	13.2	3.87	11.2	4.09	133	2.67	0.008
æ	"t**a**p"	12.4	3.87	10.3	4.36	135	2.64	0.009
ɑ	"t**o**p"	12.7	3.89	10.7	4.14	136	2.78	0.006
u	"t**oo**l"	12.8	4.26	10.9	3.64	132	2.7	0.008
ʊ	"t**oo**k"	12.9	4.05	11.0	3.95	133	2.73	0.007
ɝ	"t**ur**n"	15.0	3.00	11.3	4.01	132	4.41	<0.001
ʌ	"t**u**b"	12.6	3.89	10.9	4.15	137	2.46	0.015
ɛ	"t**e**n"	12.9	3.87	11.1	4.12	133	2.5	0.014
eɪ̯	"t**a**pe"	13.7	3.8	10.9	3.88	133	4.16	<0.001
aɪ̯	"t**ie**"	13.5	4.14	11.1	3.8	131	3.43	<0.001
oʊ̯	"t**oe**"	13.5	3.97	10.8	3.76	132	4.1	<0.001
mi	"**me**"	14.9	3.06	10.9	3.87	134	5.86	<0.001
mɪ	"**mi**t"	14.8	3.32	11.3	3.97	132	4.27	<0.001
mæ	"**ma**t"	13.5	4.06	10.7	3.68	133	4.25	<0.001
mʌ	"**mu**d"	12.8	4.01	11.2	4.02	134	2.37	0.019
mɑ	"**mo**m"	12.8	3.88	9.54	3.62	137	4.48	<0.001
mu	"**moo**"	15.2	2.85	10.2	3.56	132	8.30	<0.001
di	"**dee**p"	14.5	3.12	11.1	4.04	132	4.50	<0.001
dɪ	"**di**p"	13.9	3.38	11.0	4.10	132	4.02	<0.001
dæ	"**da**d"	13.0	3.66	8.27	3.34	138	6.34	<0.001
dʌ	"**do**ne"	13.9	3.73	10.6	3.76	133	5.02	<0.001
dɑ	"**do**g"	14.2	3.39	9.96	3.61	133	7.11	<0.001
du	"**do**"	14.0	3.55	10.7	3.91	134	4.91	<0.001
pi	"**pea**s"	16.4	1.99	10.9	3.74	133	7.45	<0.001
pɪ	"**pi**n"	16.3	2.23	11.6	3.99	131	4.05	<0.001
pæ	"**pa**ss"	13.9	4.26	11.3	3.84	132	3.29	0.001
pʌ	"**pu**tt"	13.9	3.83	11.3	3.98	131	3.35	0.001
pɑ	"**pa** pa"	13.8	3.58	9.89	3.60	135	6.42	<0.001
pu	"**poo**l"	15.2	3.09	11.4	3.97	133	4.34	<0.001
bi	"**be**"	14.9	3.13	10.8	3.89	132	5.85	<0.001
bɪ	"**bi**d"	14.2	3.73	11.3	3.98	132	3.59	<0.001
bæ	"**ba**t"	12.9	3.91	10.8	3.98	133	3.10	0.002
bʌ	"**bu**d"	12.8	3.97	10.6	3.97	132	3.08	0.003
bɑ	"**ba**ll"	12.7	3.88	9.59	3.7	139	4.12	<0.001
bu	"**boo**"	14.5	3.68	10.4	3.51	134	6.48	<0.001

ni	“**knee**”	15.2	3.42	11.4	3.95	133	4.19	<0.001
nɪ	“**kni**t”	14.7	4.04	11.6	3.95	132	3.15	0.002
næ	“**na**p”	14.2	3.76	11.0	3.84	134	4.65	<0.001
nʌ	“**nu**t”	13.8	3.69	11.3	4.07	132	3.30	0.001
nɑ	“**no**t”	14.4	3.63	11.0	3.89	131	4.61	<0.001
nu	“**new**”	15.9	3.23	11.5	3.92	133	4.33	<0.001
wi	“**wee**k”	15.1	3.57	11.2	3.84	131	4.75	<0.001
wɪ	“**wi**nd”	15.2	3.51	11.5	3.95	131	3.75	<0.001
wæ	“**wa**gon”	14.4	3.7	11.1	3.88	132	4.38	<0.001
wʌ	“**wha**t”	13.3	3.81	11.5	4.10	134	2.41	0.017
wɑ	“**wa**tt”	13.3	3.79	11	4.00	131	3.36	0.001
wu	“**woo** hoo”	14.3	3.76	10.7	3.69	131	5.37	<0.001
hi	“**he**”	14.3	3.82	11.3	3.92	132	3.81	<0.001
hɪ	“**hi**t”	14.6	3.62	11.3	3.95	132	3.90	<0.001
hæ	“**ha**t”	14.7	3.62	11.1	3.83	132	4.91	<0.001
hʌ	“**hu**t”	13.5	4.09	11.5	4	131	2.53	0.012
hɑ	“**ho**t”	14.1	4.01	11.0	3.75	133	4.44	<0.001
hu	“**who**”	15.1	3.56	11.3	3.9	132	4.36	<0.001
ti	“**tea**”	16.1	3.08	11.3	3.88	131	4.93	<0.001
tʌ	“**tu**b”	14.5	3.38	11.3	4.04	131	3.73	<0.001
tɑ	“**to**p”	14.4	3.73	11.3	3.93	132	3.91	<0.001
tu	“**two**”	16.0	2.96	11.1	3.79	133	5.97	<0.001
ki	“**key**”	15.4	3.54	11.4	3.90	132	4.50	<0.001
kʌ	“**cu**t”	15.2	3.35	11.4	3.95	133	4.30	<0.001
kɑ	“**co**p”	15.3	3.43	11.4	3.91	132	4.35	<0.001
ku	“**coo**l”	13.8	4.25	11.5	3.94	133	2.68	0.008
gi	“**gee**k”	13.7	4.25	11.4	3.89	132	2.89	0.004
gʌ	“**gu**m”	12.5	4.34	11.8	4.01	132	0.882	0.379
gɑ	“**go**t”	12.9	4.13	11.6	4.02	132	1.82	0.071
gu	“**goo**p”	13.2	4.35	11.5	3.86	133	2.33	0.021
fi	“**fee**t”	17.1	1.60	11.3	3.83	133	6.11	<0.001
fʌ	“**fu**n”	14.9	3.97	11.6	3.97	131	3.07	0.003
fɑ	“**fo**g”	15.2	3.70	11.5	3.94	132	3.66	<0.001
fu	“**foo**d”	15.1	3.36	11.4	3.95	134	4.13	<0.001
ji	“**yea**r”	14.9	2.91	11.6	4.07	132	3.18	0.002
jɪ	“**yi**ppy”	14.3	3.99	11.4	3.94	132	3.28	0.001
jæ	“**yeah**”	14.2	3.54	10.2	3.56	135	6.60	<0.001
jʌ	“**yu**m”	13.8	3.82	10.8	3.79	134	4.66	<0.001
jɑ	“**yaw**n”	13.6	4.07	11.2	3.87	132	3.29	0.001
ju	“**you**”	14.6	3.69	11.3	3.95	133	3.95	<0.001
vi	“**vea**l”	16.5	1.73	11.8	4.07	132	2.27	0.025
vɑ	“**vo**lley”	13.7	4.12	11.9	4.08	132	1.29	0.203
vu	“**voo**doo”	14.6	3.53	11.5	4.02	132	3.2	0.002

ʧi	"**chee**k"	17.2	1.40	11.5	3.93	133	4.93	<0.001
ʧʌ	"**chu**g"	16.5	2.27	11.6	3.99	132	3.81	<0.001
ʧɑ	"**cha**lk"	14.9	3.42	11.7	4.05	132	2.66	0.009
ʧu	"**chew**"	17.2	1.83	11.5	3.92	132	4.74	<0.001
ʤi	"**jee**p"	15.5	3.73	11.6	3.98	132	3.23	0.002
ʤʌ	"**ju**g"	13.5	4.27	11.9	4.07	132	1.25	0.215
ʤɑ	"**jo**b"	14.8	4.46	11.7	3.96	132	2.64	0.009
ʤu	"**jui**ce"	16.5	1.86	11.0	3.77	133	7.22	<0.001
ði	"**the**se"	16.5	1.60	11.7	4.05	133	3.3	0.001
θi	"**the**me"	16.0	1.67	11.8	4.08	132	2.51	0.013
θɑ	"**thaw**"	13.7	5.55	11.8	3.95	131	1.32	0.189
si	"**see**"	16.0	2.42	11.0	3.81	133	6.62	<0.001
sɑ	"**saw**"	15.3	3.61	11.4	3.89	131	4.24	<0.001
su	"**sou**p"	15.9	2.79	11.3	3.92	132	4.86	<0.001
zi	"**ze**bra"	16.0	2.24	11.6	4.04	131	3.56	<0.001
zu	"**zoo**"	15.2	2.55	11.6	4.08	132	3.23	0.002
ri	"**rea**ch"	16.7	2.10	11.6	3.96	132	4.26	<.001
rɑ	"**ro**ck"	14.8	3.47	11.4	3.98	132	3.84	<0.001
ru	"**roo**m"	15.2	3.38	11.6	4.01	132	3.35	0.001
li	"**lea**p"	15.4	2.33	11.8	4.09	132	2.46	0.015
lɑ	"**lo**ck"	13.5	3.63	11.7	4.11	134	1.76	0.008
lu	"**loo**p"	14.9	2.75	11.6	4.10	132	2.98	0.003
ʌʔoʊ̯	"**uh oh**"	15.4	2.58	10.2	3.5	135	9.15	<0.001
hʌp	"**hu**p" like "cup"	14.9	3.51	10.8	3.74	130	5.66	<0.001
ʘ	"kissy" noise	13.6	4.07	10.5	3.39	133	4.79	<0.001
baɪ̯	"**bye**"	15.5	2.65	9.93	3.34	133	10.1	<0.001
heɪ̯	"**hey**"	15.1	3.19	10.6	3.68	132	6.84	<0.001
!	tongue "click"	12.9	3.67	10.3	4.33	131	3.62	<0.001
ʌm	"**um**"	13.1	3.97	10.5	3.77	135	3.74	<0.001
mɑm	"**mom**"	13.6	3.5	8.82	3.2	135	7.71	<0.001
haɪ̯	"**hi**"	13.8	3.93	10.2	3.35	135	5.79	<0.001

Note. Highlighted sound/sound combinations are also reported in Table 1a.

Appendix G

Table 3b

Chi-square between Caregiver Report on the SSDS and CSBS-DP

			CSBS-DP Target: /mɑmi/		
			Yes	No	Total
SSDS Target: /mɑ/	Yes	Observed	65	39	104
		% within column	62.5%	37.5%	100.0%
	No	Observed	4	31	35
		% within column	11.4%	88.6%	100.0%
	Total	Observed	69	70	139
		% within column	49.6%	50.4%	100.0%
χ^2 (1, N = 139) = 27.3, p < 0.001					
SSDS Target: /mɑm/	Yes	Observed	64	28	92
		% within column	69.6%	30.4%	100.0%
	No	Observed	4	41	45
		% within column	8.9%	91.1%	100.0%
	Total	Observed	68	69	137
		% within column	49.6%	50.4%	100.0%
χ^2 (1, N = 137) = 44.5, p < 0.001					
SSDS Target: /mi/	Yes	Observed	31	8	39
		% within column	79.5%	20.5%	100.0%
	No	Observed	36	61	97
		% within column	37.1%	62.9%	100.0%
	Total	Observed	67	69	136
		% within column	49.3%	50.7%	100.0%
χ^2 (1, N = 136) = 20.0, p < 0.001					
			CSBS-DP Target: /dædi/		
SSDS Target: /dæ/	Yes	Observed	71	39	110
		% within column	64.5%	35.5%	100.0%
	No	Observed	4	26	30
		% within column	13.3%	86.7%	100.0%
	Total	Observed	75	65	140
		% within column	53.6%	46.4%	100.0%
χ^2 (1, N = 140) = 24.9, p < 0.001					
SSDS Target: /di/	Yes	Observed	26	9	35
		% within column	74.3%	25.7%	100%
	No	Observed	45	54	99
		% within column	45.5%	54.4%	100.0%
	Total	Observed	71	63	134
		% within column	53.0%	47.0%	100.0%
χ^2 (1, N = 134) = 8.63, p = 0.003					

			CSBS-DP Target: /beɪ̯bi/			
			Yes	No	NA	Total
SSDS Target: /bi/	Yes	Observed	20	20	0	40
		% within column	50.0%	50.0%	0.0%	100.0%
	No	Observed	6	87	1	94
		% within column	6.4%	92.6%	1.1%	100.0%
	Total	Observed	26	107	1	134

		% within column	19.4%	79.9%	0.7%	100.0%
χ^2 (2, N = 134) = 34.3, p < 0.001						
			CSBS-DP Target: /dɑg/			
SSDS Target: /dɑ/	Yes	Observed	33	30	2	65
		% within column	50.8%	46.2%	3.1%	100.0%
	No	Observed	4	66	0	70
		% within column	5.7%	94.3%	0.0%	100.0%
	Total	Observed	37	96	2	135
		% within column	27.4%	71.1%	1.5%	100.0%
χ^2 (2, N = 135) = 38.1, p < 0.001						
			CSBS-DP Target: /kɪti/			
SSDS Target: /ki/	Yes	Observed	12	10	0	22
		% within column	54.5%	45.5%	0.0%	100.0%
	No	Observed	7	104	1	112
		% within column	6.3%	92.9%	0.9%	100.0%
	Total	Observed	19	114	1	134
		% within column	14.2%	85.1%	0.7%	100.0%
χ^2 (2, N = 134) = 35.3, p < 0.001						
SSDS Target: /ti/	Yes	Observed	7	10	1	18
		% within column	38.9%	55.6%	5.6%	100.0%
	No	Observed	11	104	0	115
		% within column	9.6%	90.4%	0.0%	100.0%
	Total	Observed	18	114	1	133
		% within column	13.5%	85.7%	0.8%	100.0%
χ^2 (2, N = 133) = 18.5, p < 0.001						
			CSBS-DP Target: /bɝd/			
SSDS Target: /ɝ/	Yes	Observed	5	21	0	26
		% within column	19.2%	80.8%	0.0%	100%
	No	Observed	7	100	1	108
		% within column	6.5%	92.6%	0.9%	100.0%
	Total	Observed	12	121	1	134
		% within column	9.0%	90.3	0.7%	100.0%
χ^2 (2, N = 134) = 4.37, p = 0.113						
SSDS Target: /bʌ/	Yes	Observed	11	70	0	81
		% within column	13.6%	86.4%	0.0%	100.0%
	No	Observed	0	52	1	53
		% within column	0.0%	98.1%	1.9%	100.0%
	Total	Observed	11	122	1	134
		% within column	8.2%	91.0%	0.7%	100.0%
χ^2 (2, N = 134) = 9.21, p = 0.010						
			CSBS-DP Target: /dʌk/			
SSDS Target: /dʌ/	Yes	Observed	16	39	0	55
		% within column	29.1%	70.9%	0.0%	100.0%
	No	Observed	3	76	1	80
		% within column	3.8%	95.0%	1.3%	100.0%
	Total	Observed	19	115	1	135
		% within column	14.1%	85.2%	0.7%	100.0%
χ^2 (2, N = 135) = 17.8, p < 0.001						
			CSBS-DP Target: /aɪ̯/			

SSDS Target: /aɪ̯/	Yes	Observed	11	42	0	53
		% within column	20.8%	79.2%	0.0%	100.0%
	No	Observed	3	76	1	80
		% within column	3.8%	95.0%	1.3%	100.0%
	Total	Observed	14	118	1	135
		% within column	10.5%	88.7%	0.8%	100.0%
χ^2 (2, N = 135) = 10.3, p = 0.006						
			CSBS-DP Target: /noʊ̯z/			
SSDS Target: /oʊ̯/	Yes	Observed	19	46	0	65
		% within column	29.2%	70.8%	0.0%	100.0%
	No	Observed	5	63	1	69
		% within column	7.2%	91.3%	1.4%	100.0%
	Total	Observed	24	109	1	134
		% within column	17.9%	81.3%	0.7%	100.0%
χ^2 (2, N = 134) = 11.7, p = 0.003						
			CSBS-DP Target: /mu/			
SSDS Target: /mu/	Yes	Observed	27	19	1	47
		% within column	57.4%	40.4%	2.1%	100.0%
	No	Observed	1	86	0	87
		% within column	1.1%	98.9%	0.0%	100.0%
	Total	Observed	28	105	1	134
		% within column	20.9%	78.4%	0.7%	100.0%
χ^2 (2, N = 134) = 61.4, p < 0.001						
			CSBS-DP Target: /gɝ/			
SSDS Target: /ɝ/	Yes	Observed	16	10	0	26
		% within column	61.5%	38.5%	0.0%	100.0%
	No	Observed	23	84	1	108
		% within column	21.3%	77.8%	0.9%	100.0%
	Total	Observed	39	94	1	134
		% within column	29.1%	70.1%	0.7%	100.0%
χ^2 (2, N = 134) = 16.5, p < 0.001						
			CSBS-DP Target: /pikʌbu/			
SSDS Target: /pi/	Yes	Observed	16	12	0	28
		% within column	57.1%	42.9%	0.0%	100.0%
	No	Observed	8	98	1	107
		% within column	7.5%	91.6%	0.9%	100.0%
	Total	Observed	24	110	1	135
		% within column	17.8%	81.5%	0.7%	100.0%
χ^2 (2, N = 135) = 37.5, p < 0.001						
SSDS Target: /kʌ/	Yes	Observed	8	15	0	23
		% within column	34.8%	65.2%	0.0%	100.0%
	No	Observed	16	95	1	112
		% within column	14.3%	84.8%	0.9%	100.0%
	Total	Observed	24	110	1	135
		% within column	17.8%	81.5%	0.7%	100.0%
χ^2 (2, N = 135) = 5.61, p = 0.060						
SSDS Target: /bu/	Yes	Observed	20	19	1	47
		% within column	37.7%	40.4%	2.1%	100.0%
	No	Observed	4	86	0	87

		% within column	4.8%	98.9%	0.0%	100.0%
	Total	Observed	24	105	1	134
		% within column	17.6%	78.4%	0.7%	100.0%
χ^2 (2, N = 134) = 24.5, p < 0.001						
				CSBS-DP Target: /baɪ̯ baɪ̯/		
SSDS Target: /baɪ̯/	Yes	Observed	39	12	0	51
		% within column	76.5%	23.5%	0.0%	100.0%
	No	Observed	5	78	1	84
		% within column	6.0%	92.9%	1.2%	100.0%
	Total	Observed	44	90	1	135
		% within column	32.6%	66.7%	0.7%	100.0%
χ^2 (2, N = 135) = 71.9, p < 0.001						
				CSBS-DP Target: /noʊ̯/		
SSDS Target: /nʌ/	Yes	Observed	20	17	0	37
		% within column	54.1%	45.9%	0.0%	100.0%
	No	Observed	19	77	1	97
		% within column	19.6%	79.4%	1.0%	100.0%
	Total	Observed	39	94	1	134
		% within column	29.1%	70.1%	0.7%	100.0%
χ^2 (2, N = 134) = 15.6, p < 0.001						
SSDS Target: /næ/	Yes	Observed	22	21	0	43
		% within column	51.2%	48.8%	0.0%	100.0%
	No	Observed	17	75	1	93
		% within column	18.3%	80.6%	1.1%	100.0%
	Total	Observed	39	96	1	136
		% within column	28.7%	70.6%	0.7%	100.0%
χ^2 (2, N = 136) = 15.8, p < 0.001						
SSDS Target: /oʊ̯/	Yes	Observed	28	37	0	65
		% within column	43.1%	56.9%	0.0%	100.0%
	No	Observed	11	57	1	69
		% within column	15.9%	82.6%	1.4%	100.0%
	Total	Observed	39	94	1	134
		% within column	29.1%	70.1%	0.7%	100.0%
χ^2 (2, N = 134) = 12.6, p = 0.002						
				CSBS-DP Target: /haɪ̯/		
SSDS Target: /haɪ̯/	Yes	Observed	48	21	0	69
		% within column	69.6%	30.4%	0.0%	100.0%
	No	Observed	2	65	1	68
		% within column	2.9%	95.6%	1.5%	100.0%
	Total	Observed	50	86	1	137
		% within column	36.5%	62.8%	0.7%	100.0%
χ^2 (2, N = 137) = 65.8, p < 0.001						
				CSBS-DP Target: /ɑlgɑn/		
SSDS Target: /ɑ/	Yes	Observed	19	69	1	89
		% within column	21.3%	77.5%	1.1%	100.0%
	No	Observed	8	41	0	49
		% within column	16.3%	83.7%	0.0%	100.0%
	Total	Observed	27	110	1	138
		% within column	19.6%	79.7%	0.7%	100.0%

χ^2 (2, N = 138) = 1.11, p = 0.575

SSDS Target: /gɑ/	Yes	Observed	12	30	0	42
		% within column	28.6%	71.4%	0.0%	100.0%
	No	Observed	14	77	1	92
		% within column	15.2%	83.7%	1.1%	100.0%
	Total	Observed	26	107	1	134
		% within column	19.4%	79.9%	0.7%	100.0%

χ^2 (2, N = 134) = 3.65, p = 0.161

SSDS Target: /gʌ/	Yes	Observed	12	24	0	36
		% within column	33.3%	66.7%	0.0%	100.0%
	No	Observed	14	83	1	98
		% within column	14.3%	84.7%	1.0%	100.0%
	Total	Observed	26	107	1	134
		% within column	19.4%	79.9%	0.7%	100.0%

χ^2 (2, N = 134) = 6.36, p = 0.042

			CSBS-DP Target: /ʌʔoʊ̯/			
SSDS Target: /ʌʔoʊ̯/	Yes	Observed	41	7	0	48
		% within column	85.4%	14.6%	0.0%	100.0%
	No	Observed	3	85	1	89
		% within column	3.4%	95.5%	1.1%	100.0%
	Total	Observed	44	92	1	137
		% within column	32.1%	67.2%	0.7%	100.0%

χ^2 (2, N = 137) = 96.3, p < 0.001

			CSBS-DP Target: /naɪ̯t naɪ̯t/			
SSDS Target: /nʌ/	Yes	Observed	16	21	0	37
		% within column	43.2%	56.8%	0.0%	100.0%
	No	Observed	5	91	1	97
		% within column	5.2%	93.8%	1.0%	100.0%
	Total	Observed	21	112	1	134
		% within column	15.7%	83.6%	0.7%	100.0%

χ^2 (2, N = 134) = 29.6, p < 0.001

SSDS Target: /aɪ̯/	Yes	Observed	15	38	0	53
		% within column	28.3%	71.7%	0.0%	100.0%
	No	Observed	5	74	1	80
		% within column	6.39%	92.5%	1.3%	100.0%
	Total	Observed	20	112	1	133
		% within column	15.0%	84.2%	0.8%	100.0%

χ^2 (2, N = 133) = 12.6, p = 0.002

			CSBS-DP Target: /aʊ̯t saɪ̯d/			
SSDS Target: /aɪ̯/	Yes	Observed	9	44	0	53
		% within column	17.0%	83.0%	0.0%	100.0%
	No	Observed	0	79	1	80
		% within column	0.0%	98.8%	1.3%	100.0%
	Total	Observed	9	123	1	133
		% within column	6.8%	92.5%	0.8%	100.0%

χ^2 (2, N = 133) = 15.1, p < 0.001

			CSBS-DP Target: /jʌm jʌm/			
	Yes	Observed	25	31	0	56
		% within column	44.6%	55.4%	0.0%	100.0%

SSDS Target: /jʌ/	No	Observed	5	74	1	80
		% within column	6.3%	92.5%	1.3%	100.0%
	Total	Observed	30	105	1	136
		% within column	22.1%	77.2%	0.7%	100.0%
χ^2 (2, N = 136) = 15.1, p < 0.001						
SSDS Target: /ʌm/	Yes	Observed	27	54	0	81
		% within column	33.3%	66.7%	0.0%	100.0%
	No	Observed	3	52	1	56
		% within column	5.4%	92.9%	1.8%	100.0%
	Total	Observed	30	106	1	137
		% within column	21.9%	77.4%	0.7%	100.0%
χ^2 (2, N = 137) = 15.1, p < 0.001						
			CSBS-DP Target: /vrum/			
SSDS Target: /vu/	Yes	Observed	9	11	0	20
		% within column	45.0%	55.0%	0.0%	100.0%
	No	Observed	14	99	1	114
		% within column	12.3%	86.8%	0.9%	100.0%
	Total	Observed	23	110	1	134
		% within column	17.2%	82.1%	0.7%	100.0%
χ^2 (2, N = 134) = 12.9, p = 0.002						
SSDS Target: /ru/	Yes	Observed	7	8	0	15
		% within column	46.7%	53.3%	0.0%	100.0%
	No	Observed	16	102	1	119
		% within column	13.4%	85.7%	0.8%	100.0%
	Total	Observed	23	110	1	134
		% within column	17.2%	82.1%	0.7%	100.0%
χ^2 (2, N = 134) = 10.4, p = 0.006						
			CSBS-DP Target: /ʌp/			
SSDS Target: /hʌp/	Yes	Observed	18	18	0	36
		% within column	50.0%	50.0%	0.0%	100.0%
	No	Observed	7	88	1	96
		% within column	7.3%	91.7%	1.0%	100.0%
	Total	Observed	25	106	1	132
		% within column	18.9%	80.3%	0.8%	100.0%
χ^2 (2, N = 132) = 31.3, p < 0.001						
			CSBS-DP Target: /bɑtəl/			
SSDS Target: /bɑ/	Yes	Observed	26	81	0	107
		% within column	24.3%	75.7%	0.0%	100.0%
	No	Observed	2	31	1	34
		% within column	5.9%	91.2%	2.9%	100.0%
	Total	Observed	28	112	1	141
		% within column	19.9%	79.4%	0.7%	100.0%
χ^2 (2, N = 141) = 8.33, p = 0.016						
SSDS Target: /dʌ/	Yes	Observed	19	36	0	55
		% within column	34.5%	65.5%	0.0%	100.0%
	No	Observed	9	70	1	80
		% within column	11.3%	87.5%	1.3%	100.0%
	Total	Observed	28	106	1	135
		% within column	20.7%	78.5%	0.7%	100.0%

χ^2 (2, N = 135) = 11.2, p = 0.004						
SSDS Target: /tʌ/	Yes	Observed	12	15	0	27
		% within column	44.4%	55.6%	0.0%	100.0%
	No	Observed	14	91	1	106
		% within column	13.2%	85.8%	0.9%	100.0%
	Total	Observed	26	106	1	133
		% within column	19.5%	79.7%	0.8%	100.0%
χ^2 (2, N = 133) = 13.5, p = 0.001						
			CSBS-DP Target: /bʌnɑnʌ/ or /bʌnænʌ/			
SSDS Target: /bʌ/	Yes	Observed	19	62	0	81
		% within column	23.5%	76.5%	0.0%	100.0%
	No	Observed	2	50	1	53
		% within column	3.8%	94.3%	1.9%	100.0%
	Total	Observed	21	112	1	134
		% within column	15.7%	83.6%	0.7%	100.0%
χ^2 (2, N = 134) = 10.7, p = 0.005						
SSDS Target: /nɑ/	Yes	Observed	13	24	0	37
		% within column	35.1%	64.9%	0.0%	100.0%
	No	Observed	9	86	1	96
		% within column	9.4%	89.6%	1.0%	100.0%
	Total	Observed	22	110	1	133
		% within column	16.5%	82.7%	0.78%	100.0%
χ^2 (2, N = 133) = 13.1, p = 0.001						
SSDS Target: /næ/	Yes	Observed	17	26	0	43
		% within column	39.5%	60.5%	0.0%	100.0%
	No	Observed	6	86	1	93
		% within column	6.5%	92.5%	1.1%	100.0%
	Total	Observed	23	112	1	136
		% within column	16.9%	82.4%	0.7%	100.0%
χ^2 (2, N = 136) = 23.2, p < 0.001						
SSDS Target: /nʌ/	Yes	Observed	10	27	0	37
		% within column	27.0%	73.0%	0.0%	100.0%
	No	Observed	13	83	1	97
		% within column	13.4%	85.6%	1.0%	100.0%
	Total	Observed	23	110	1	134
		% within column	17.2%	82.1%	0.7%	100.0%
χ^2 (2, N = 134) = 3.8, p = 0.150						
			CSBS-DP Target: /bɑl/			
SSDS Target: /bɑ/	Yes	Observed	30	77	0	107
		% within column	28.0%	72.0%	0.0%	100.0%
	No	Observed	2	31	1	34
		% within column	5.9%	91.2%	2.9%	100.0%
	Total	Observed	32	108	1	141
		% within column	22.7%	76.6%	0.7%	100.0%
χ^2 (2, N = 141) = 9.97, p = 0.007						
SSDS Target: /bʌ/	Yes	Observed	26	55	0	81
		% within column	32.1%	67.9%	0.0%	100.0%
	No	Observed	5	47	1	53
		% within column	9.4%	88.7%	1.9%	100.0%

	Total	Observed	31	102	1	134
		% within column	23.1%	76.1%	0.7%	100.0%
χ^2 (2, N = 134) = 10.5, p = 0.005						
			CSBS-DP Target: /bæθ/			
SSDS Target: /bæ/	Yes	Observed	13	61	0	74
		% within column	17.6%	82.4%	0.0%	100.0%
	No	Observed	2	58	1	61
		% within column	3.3%	95.1%	1.6%	100.0%
	Total	Observed	15	119	1	135
		% within column	11.1%	88.1%	0.7%	100.0%
χ^2 (2, N = 135) = 7.96, p = 0.019						
			CSBS-DP Target: /bʊk/			
SSDS Target: /ʊ/	Yes	Observed	12	60	0	72
		% within column	16.7%	83.3%	0.0%	100.0%
	No	Observed	3	59	1	63
		% within column	4.8%	93.7%	1.6%	100.0%
	Total	Observed	15	119	1	135
		% within column	11.1%	88.1%	0.7%	100.0%
χ^2 (2, N = 135) = 5.83, p = 0.054						
			CSBS-DP Target: /kɑr/			
SSDS Target: /kɑ/	Yes	Observed	5	16	0	21
		% within column	23.8%	76.2%	0.0%	100.0%
	No	Observed	5	107	1	113
		% within column	4.4%	94.7%	0.9%	100.0%
	Total	Observed	10	123	1	134
		% within column	7.5%	91.8%	0.7%	100.0%
χ^2 (2, N = 134) = 9.76, p = 0.008						
			CSBS-DP Target: /kʊki/			
SSDS Target: /ʊ/	Yes	Observed	8	64	0	72
		% within column	11.1%	88.9%	0.0%	100.0%
	No	Observed	2	60	1	63
		% within column	3.2%	95.2%	1.6%	100.0%
	Total	Observed	10	124	1	135
		% within column	7.4%	91.9%	0.7%	100.0%
χ^2 (2, N = 135) = 7.96, p = 0.126						
SSDS Target: /ki/	Yes	Observed	9	13	0	22
		% within column	40.9%	59.1%	0.0%	100.0%
	No	Observed	1	110	1	112
		% within column	0.9%	98.2%	0.9%	100.0%
	Total	Observed	10	123	1	134
		% within column	7.5%	91.8%	0.7%	100.0%
χ^2 (2, N = 134) = 42.7, p < 0.001						
			CSBS-DP Target: /dʒus/			
SSDS Target: /dʒu/	Yes	Observed	10	16	0	26
		% within column	38.5%	61.5%	0.0%	100.0%
	No	Observed	1	107	1	109
		% within column	0.9%	98.2%	0.9%	100.0%
	Total	Observed	11	123	1	135
		% within column	8.1%	91.1%	0.7%	100.0%

χ^2 (2, N = 135) = 39.6, p < 0.001						
			CSBS-DP Target: /sɑk/			
SSDS Target: /sɑ/	Yes	Observed	9	12	0	21
		% within column	42.9%	57.1%	0.0%	100.0%
	No	Observed	4	107	1	112
		% within column	3.6%	95.5%	0.9%	100.0%
	Total	Observed	13	119	1	133
		% within column	9.8%	89.5%	0.8%	100.0%
χ^2 (2, N = 133) = 7.96, p < 0.001						
			CSBS-DP Target: /kiz/			
SSDS Target: /ki/	Yes	Observed	7	15	0	22
		% within column	31.8%	68.2%	0.0%	100.0%
	No	Observed	1	110	1	112
		% within column	0.9%	98.2%	0.9%	100.0%
	Total	Observed	8	125	1	134
		% within column	6.0%	93.3%	0.7%	100.0%
χ^2 (2, N = 134) =31.4, p < 0.001						
			CSBS-DP Target: /bʌlun/			
SSDS Target: /bʌ/	Yes	Observed	7	74	0	81
		% within column	8.6%	91.4%	0.0%	100.0%
	No	Observed	1	51	1	53
		% within column	1.9%	96.2%	1.9%	100.0%
	Total	Observed	8	125	1	134
		% within column	6.0%	93.3%	0.7%	100.0%
χ^2 (2, N = 134) = 4.06, p = 0.1312						
SSDS Target: /lu/	Yes	Observed	1	14	0	15
		% within column	6.7%	93.3%	0.0%	100.0%
	No	Observed	7	111	1	119
		% within column	5.9%	93.3%	0.8%	100.0%
	Total	Observed	8	119	1	134
		% within column	6.0%	93.3%	0.7%	100.0%
χ^2 (2, N = 134) = 0.140, p = 0.932						
			CSBS-DP Target: /trʌk/			
SSDS Target: /ʌ/	Yes	Observed	8	82	1	91
		% within column	8.8%	90.1%	1.1%	100.0%
	No	Observed	1	47	0	48
		% within column	2.1%	97.9%	0.0%	100.0%
	Total	Observed	9	129	1	139
		% within column	6.5%	92.8%	0.7%	100.0%
χ^2 (2, N = 139) = 2.92, p = 0.233						
SSDS Target: /tʌ/	Yes	Observed	6	21	0	27
		% within column	22.2%	79.8%	0.0%	100.0%
	No	Observed	3	102	1	106
		% within column	2.8%	96.2%	0.9%	100.0%
	Total	Observed	9	123	1	133
		% within column	6.8%	92.5%	0.8%	100.0%
χ^2 (2, N = 133) = 13.0, p = 0.001						