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Research Article

Spanish Pediatric Speech Recognition Threshold Test

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Purpose: The purpose of this study was to construct a recorded speech recognition threshold (SRT) test for Spanish-speaking children utilizing a picture board and a picture-pointing task.
Design: The Spanish Pediatric Speech Recognition Threshold (SPSRT) test was developed and validated in this study. Test construction steps included (a) stimulus selection, (b) assessment of familiarity, (c) digital recording, (d) creation of pictures that accurately depicted the target word from the stimulus set, and (e) validation of the test and recordings. SRTs were obtained from 24 Spanish-speaking children whose 1st language was Spanish.
Results: Normative data are presented that validate the SPSRT and establish the baseline relationship between the pure-tone average and the SRT obtained with the SPSRT. Results indicated that the SPSRT obtained using this test should be within 2–12 dB of an individual's pure-tone average for Spanish-speaking children with normal hearing and minimal hearing loss.
Conclusions: The SPSRT was developed and validated as a picture-pointing Spanish SRT test to be used with Spanish-speaking children. The 2-channel recording contains an English translation track, making this test easy to administer and interpret for clinicians without knowledge of Spanish.

U.S. Census Bureau statistics indicate that the Hispanic population constitutes 17.8% of the nation's total population, making people of Hispanic origin the nation's largest ethnic or racial minority (U.S. Census Bureau, n.d.). This growing segment of the population has become more visible in audiology clinics throughout the country. Although most health care fields have sought out efficient methods to accommodate the needs of non–English-speaking patients, the field of audiology remains in need of standardized, recorded, and commercially available speech perception test materials for evaluating this population. Few speech recognition threshold (SRT) tests for Spanish-speaking children have been developed to date, and those that have were created many years ago and are not commercially available (Martin & Hart, 1978; Schneider, 1992; Spitzer, 1980). Because most clinics lack access to bilingual audiologists or interpreters, clinicians who are not fluent in the Spanish language need a standardized, recorded SRT test that can be utilized easily.

As part of a standard audiological evaluation, the SRT is used to evaluate the lowest level at which an individual can recognize speech 50% of the time and should be similar to one's pure-tone average (PTA). The SRT is a fundamental component of the audiologic test battery as it often serves as a reference point for suprathreshold testing and can aid in determining hearing sensitivity for young children or those who are difficult to test. Lack of PTA-SRT agreement is diagnostically significant as it could imply the presence of pseudohypacusis or retrocochlear/central dysfunction. SRT and PTA agreement is central to audiologic assessment as it indicates consistency in threshold responses to both speech and tonal stimuli. Any test that purports to measure SRT should establish the baseline relationship between it and the corresponding PTA.

The development of a standardized speech recognition test requires important steps to be followed in order for appropriate validity and reliability to be established (Elkins, 1984; Linquist, 1953). The stimuli selected should be appropriate for the target population and have established content and construct validity (Mendel & Danhauer, 1997). Due to children's developing vocabulary, it is important that the

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stimuli have linguistic characteristics consistent with a child's native language. One of the challenges faced in developing a test in Spanish is that the stress patterns of Spanish and English differ. Specifically, spondaic words are uncommon in Spanish, and more than half of the words in Spanish have stress on the second to the last syllable (Gaeta & John, 2015).

In addition, the stimuli should have a high degree of familiarity (Epstein, Giolas, & Owens, 1968; Owens, 1961). In the past, creators of speech audiometry tests constructed their stimulus set from newspapers, books, and other common reading materials to obtain the most frequently used words of the language at that time (Elliott, Clifton, & Servi, 1983; Martin & Hart, 1978; Mendel & Danhauer, 1997; Spitzer, 1980). The more frequently a word appears in a language, typically, the more familiar the word is to the average individual. This familiarity then lends itself to higher recognition ability for listening tasks. Thus, use of unfamiliar words jeopardizes assessment of correct perception abilities by native and nonnative listeners.

The format of the test should also be determined with particular consideration as to whether the test is open- or closed-set (Gutnick & St. John, 1982; Mendel & Danhauer, 1997; Spitzer & Osborne, 1980). The conventional method for obtaining an SRT consists of presenting a set of target words with descending intensity, and the child responds by repeating the target word (open-set paradigm) or by pointing to a picture of the word (closed-set paradigm). Using an open-set response method proves challenging for the audiologist who is unfamiliar with the Spanish language. By using a picture-pointing, closed-set task, the audiologist can easily score responses by determining if the appropriate picture was selected by the child. When a picture board is used, it is important that the picture is an accurate representation of each stimulus item.

Use of recorded stimuli for any test of speech perception is considered the standard of practice that is required for reliability and accurate diagnosis and treatment recommendations (Mendel & Danhauer, 1997; Mendel & Owen, 2011; Roeser & Clark, 2008; Rourke-Cullen, Ninya, & Nerbonne, 1995). When the method of stimulus presentation is not controlled, as can be the case with monitored live voice, considerable variability may result and consequently jeopardize the reliability and standardization of the findings. Standardization of speech recognition materials is essential for reliability to be ensured. When standardized, test–retest data can be compared between examiners and clinics.

The final step in test development requires that the stimulus set be validated on the population of interest. Appropriate standardization data are necessary for a speech perception test to be considered valid and reliable. Thus, the purpose of this study was to construct and validate the Spanish Pediatric Speech Recognition Threshold (SPSRT) test for Spanish-speaking children utilizing a picture board and picture-pointing task. Using a two-channel recording of fluent Spanish and English speakers, this test can be administered and interpreted by clinicians without knowledge of Spanish.

Method

Stimulus Selection

Several decisions were made regarding the stimuli selected for the SPSRT picture board. Because the Spanish language has very few spondaic words, that is, words with equal emphasis on both syllables, trochaic words were used instead. Trochaic stress is the most frequently used stress pattern in Spanish, which consists of a stressed syllable followed by an unstressed syllable (Gaeta & John, 2015; Martin & Hart, 1978). Another consideration was the need for each stimulus item to be presented pictorially and be easily recognized by children. In addition, the type of pictorial representation had to be determined as to whether the pictures would be actual photographs or illustrated pictures. Furthermore, to avoid providing extra cues to the listener, gender-identifying articles such as "*el*" or "*la*" were not used. Lastly, the stimuli needed to have a high degree of familiarity for a pediatric population.

One hundred words matching the above criteria were chosen from *A Frequency Dictionary of Spanish: Core Vocabulary for Learners* (Davies, 2006). However, because words in a dictionary are based on their frequency of usage and not on word familiarity, a familiarity rating scale was incorporated to determine the degree of familiarity of the stimuli.

Familiarity Ratings

Twelve Spanish-speaking adults of Latin American descent were asked to rate how familiar a set of 100 words would be to a child between the ages of 2 and 5 years. Instructions were presented in Spanish to the participants in writing and/or via an interpreter. The familiarity scale ranged from 1 to 5 with the following descriptors: 1 = *extremely familiar*, 2 = *very familiar*, 3 = *average familiarity*, 4 = *vaguely familiar*, and 5 = *unfamiliar*. Words that were given a rating of 4 or 5 were discarded. The remaining words were rank-ordered according to the familiarity ratings of 1, 2, or 3, resulting in a total of 37 words. From these, 25 words were selected based on the ease of pictorial representation and elimination of repetitive or similar words, such as *woman* and *girl* or *elbow* and *arm*.

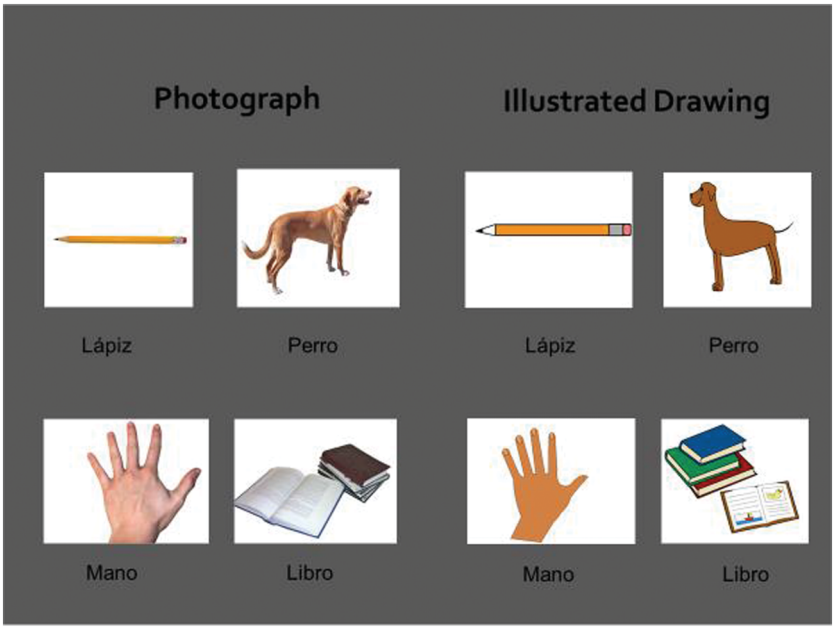
Initial Stimulus Set

Appendix A lists the initial stimulus set that included 25 words that were ranked with high familiarity and matched the criteria stated above. Many of these words were tangible objects or food items found in a child's everyday environment, such as *bed*, *egg, milk, juice, table, dog, cup,* and *chair*, as well as common body parts, such as *finger, eye, ear,* and *nose*.

Pictorial Representation

Actual photographs and illustrated drawings were created for each of the 25 stimulus items in the initial set. Figure 1 displays a sample of these pictures for four stimulus items. These pictorial representations were placed on flash cards for a total of 50 items (25 photos and 25 digitally drawn) and presented to 25 Spanish-speaking children of Latin

Figure 1. Examples of actual photographs and illustrated drawings for four stimulus items (Lápiz: pencil; Perro: dog; Mano: hand; and Libro: book) in the initial set.



American descent (14 boys, 11 girls), aged 3–11 years (M = 9 years), in random order. The children were shown each picture on a single flash card and asked, "Que es (*What is*)?" to have them verbally name the picture. The children verbally identified the picture if they recognized the image.

Digital Recordings

Digital recordings of the stimuli were produced using fluent Spanish and English speakers. For the Spanish words, a 50-year-old native Spanish-speaking woman from Mexico, fluent in both Spanish and English, produced the recordings. A tie-clip electret condenser lapel microphone was placed 3 in. from the talker's mouth, and the talker produced a carrier phrase followed by each stimulus word as it would occur naturally. She was instructed to speak using natural speaking rate and intonation. The carrier phrase, "Enseñame (Show me)," was recorded and inserted prior to each stimulus item to introduce each target word and help signal the listener. Each stimulus item was recorded four times, and the second or third presentation of each word was used in the final stimulus recording to avoid any variation in intonation during production. A Marantz Professional Solid State Digital Recorder (PMD660) was used, and Adobe Audition (Version 2.0) was used in post-production to ensure that all stimuli were leveled such that their amplitude was consistent. A 1000-Hz calibration tone was created, and a 2-s interstimulus interval was inserted between stimuli. The stimuli were presented on the recording in the same order that the 12 pictorial representations were located on the picture board. In addition, all 12 stimuli were repeated several times in randomized order in later tracks on the recording.

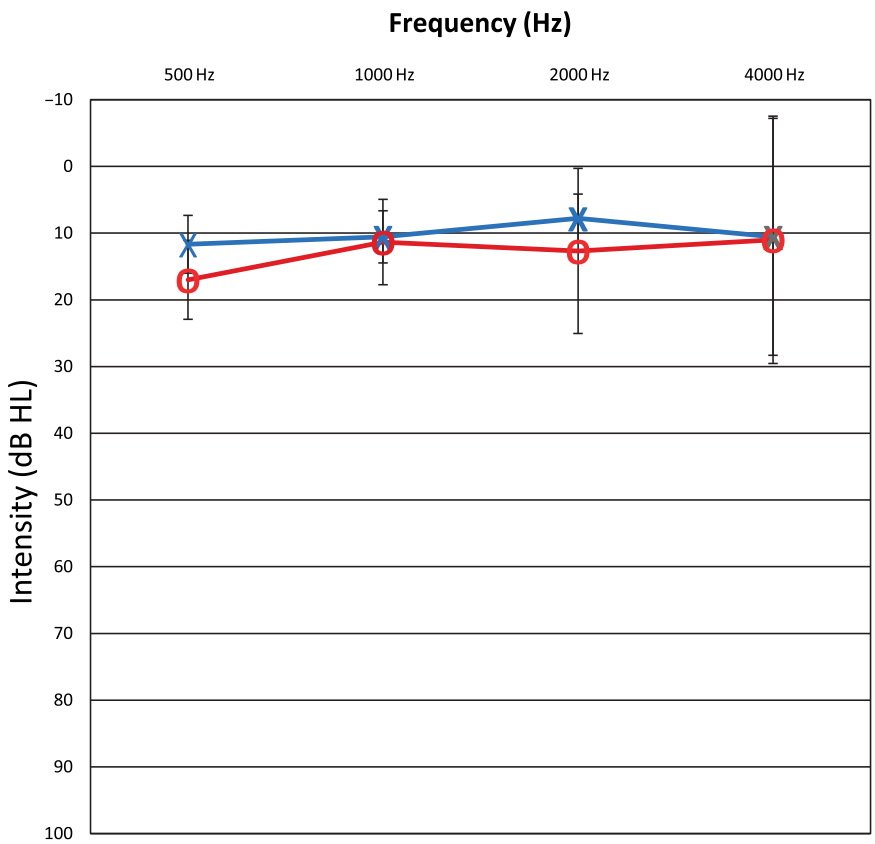
For the English translation, a 22-year-old native English-speaking woman spoke the translation of each of the 12 stimuli using the recording parameters as indicated above. Thus, a two-channel recording was created such that the Spanish target word is presented to the listener via one channel while simultaneously presenting the English translation to the examiner. In this way, the examiner can easily score the test based on the picture-pointing response.

Validation of the Recordings and SPSRT Picture Board

Participants

Twenty-four Spanish-speaking children (nine female, 15 male), aged 4–15 years (M = 8.8 years), were enrolled in the validation portion of this study. All participants were of Hispanic heritage from a variety of countries (Puerto Rico, Mexico, Peru, Guatemala, Ecuador, El Salvador, and Honduras) with Spanish as their first language. All participants had normal middle ear function as evidenced by a Type A tympanogram in the test ear on the day of testing. The test ear was the better ear for each participant. Air-conduction thresholds were obtained at octave frequencies between 500 and 4000 Hz. Figure 2 represents the composite audiogram of the test ears for the children. Seven children had minimal hearing loss with PTAs ≥ 22 dB; the remaining participants had hearing within normal limits (hearing thresholds ≤ 20 dB). Table 1 shows the mean PTAs and the variation of thresholds at each frequency for the 24 participants.

Figure 2. Composite audiogram of all ears tested. Right ear air-conduction thresholds are represented by O, and left ear air-conduction thresholds are represented by X.



Instrumentation

Validation data were collected in Memphis, Tennessee, at St. Jude Children's Research Hospital (SJCRH). The participants were tested in a sound-treated booth meeting American National Standards Institute standard S3.1-1999 (ANSI, 2013) at SJCRH. Air-conduction thresholds were obtained using a Grason-Stadler Inc. AudioPro audiometer with E-A-RTONE 3A insert earphones unless the child would not tolerate insert phones. In that case, Sennheiser (HDA 200) supra-aural headphones were used. Tympanograms were obtained using Grason-Stadler Inc. Tympstar and Tympstar Pro tympanometers. The stimuli were presented using a Sony CD player (SCD-CE595).

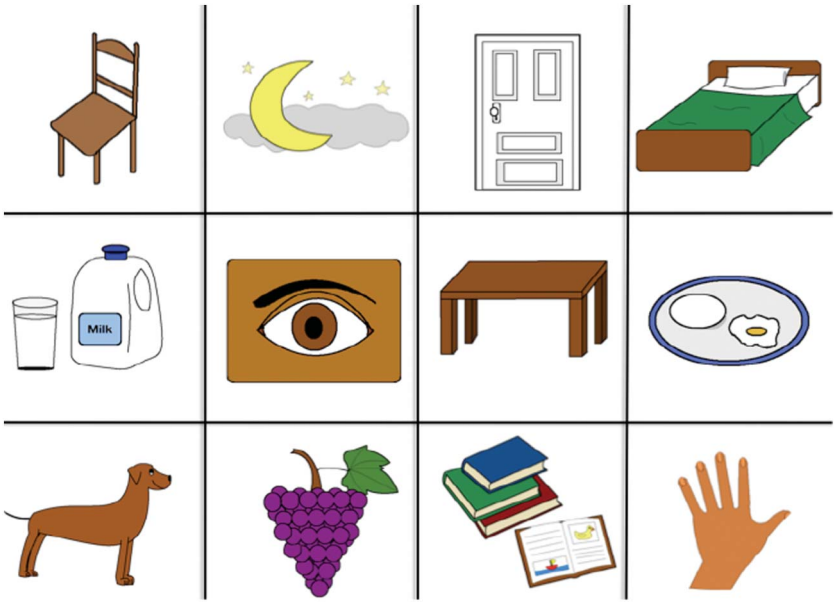
Procedure

Prior to data collection, all participants (and/or their parents) signed an informed consent approved by the University of Memphis Institutional Review Board for participation in this study, and basic ethical precautions were taken for the protection of the research participants throughout the project. Participants also signed an informed consent approved by the SJCRH Institutional Review Board. After otoscopy was performed and tympanometry and hearing thresholds were obtained, SRTs were acquired using a modified Martin and Stauffer (1975) 5-dB step SRT procedure (American Speech-Language-Hearing Association, 1988). The children were familiarized with the pictures and the task. All stimuli were presented to the child at a level 30–40 dB above his or her three-frequency PTA (500, 1000, and 2000 Hz). Participants pointed to the picture that represented the word they heard using the picture board in Figure 3. If the child did not respond correctly to the first stimulus word at the first level, then the level was increased in 20-dB steps until a correct response was obtained. Then 10-dB decrements were initiated. When one word was missed, a second stimulus word at the same level was presented. The process of descending in 10-dB steps was continued until a level was reached at which two consecutive words were missed at the same hearing level. This level was then increased by 10 dB (above the level at which two stimulus words were missed) to define the starting level. Once the starting level was established, five words were presented at

Table 1. Pure-tone averages (PTAs) and minimum and maximum thresholds at each frequency (in dB) for the 24 participants.

Variable	500 Hz	1000 Hz	2000 Hz	4000 Hz	PTA
Minimum threshold	5	0	0	0	3
Maximum threshold	30	20	50	75	32
M	15	11	11	11	12

Figure 3. Final Spanish Pediatric Speech Recognition Threshold picture board.



each level, decreasing in 5-dB steps. The descending series was terminated when no words at a single intensity were correctly recognized. Following completion of the testing, the SRT was calculated using the following formula from the American Speech-Language-Hearing Association (1988) guidelines: [number of correct responses + 2 (correction factor)], which was subtracted from the starting level.

Results

Picture Identification

Figure 4 displays the picture identification results. Words were deemed correct if the child identified the picture using the correct target word spoken in Spanish. Words labeled correctly with ≥ 80% accuracy are shown above the black line. The children's ability to recognize the singular and/or plural forms of "libro" and "huevo" was very similar, although slightly better with the plural form of "libro." Since this was a picture-pointing task and the goal was to create easily identifiable pictorial representations, we opted to use the plural picture for "libro" and "huevo." However, when recorded, these stimuli were presented in their singular form.

Final SPSRT Picture Board

A *t* test revealed no statistically significant difference between the children's ability to recognize photographs or digitally illustrated stimulus items ($t = 334.5$, $p = .198$). Therefore, the 12 words with the highest percentage of correct responses were averaged, revealing that the "drawn" pictures (95%) received slightly higher correct percentages than the "real" pictures (92.25%). Thus, the 12 digitally illustrated stimulus items with the highest percentages were included in the final stimulus set consisting of colored, computer-generated images of the representative stimulus items and assembled into a 12-item picture board. Appendix B lists the stimulus items on the final picture board, which is displayed in Figure 3.

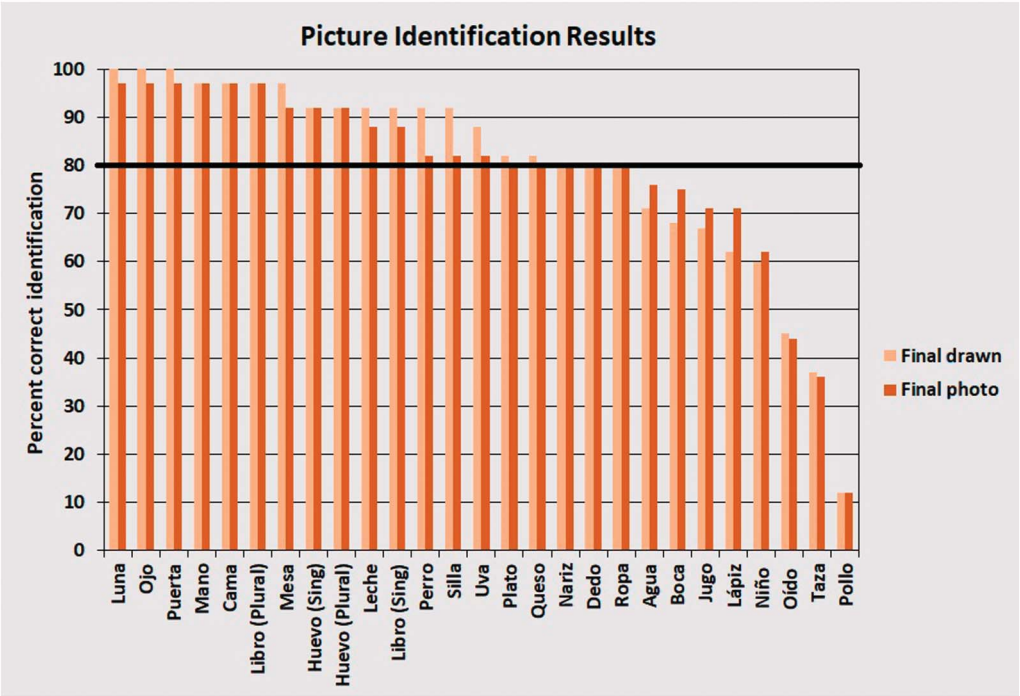
Validation of the Recordings and SPSRT Picture Board

Table 2 shows the results indicating the average PTA (500, 1000, and 2000 Hz) was 12 dB and the average SRT was 2 dB, with a mean difference between PTA and SRT of 10 dB across all participants. A Pearson product–moment correlation between PTA and SRT for the SJCRH data revealed a significant positive correlation of .75 ($p = .00002$). We also calculated a four-frequency PTA (500, 1000, 2000, and 4000 Hz) that resulted in a significant positive correlation of .83 ($p < .001$). The range of PTAs and SRTs was the same as those reported in Table 2.

Discussion

The goal of this study was to develop and validate the SPSRT as a picture-pointing Spanish SRT test to be used with Spanish-speaking children. Several steps were followed in the standardization of this test including stimulus selection and familiarity ratings, pictorial representation of the stimuli, audio recordings, and validation of the recordings and picture board (Elkins, 1984; Mendel & Danhauer, 1997). The familiarity rating task ensured that the pictures on the final SPSRT picture board were at an appropriate level for the participants. This familiarity, along with accurate

Figure 4. Percent correct identification of pictures (photographs and digital illustrations) by children. Stimulus items with correct identification of ≥ 80% (above the black line) were selected for the final stimulus set.



pictorial representation of each item, contributed to the consistency with which the participants were able to accurately identify the pictures on the picture board.

The normative data presented here on the SPSRT recordings validated the SPSRT and established the baseline relationship between the SPSRT and the PTA. Results indicated that the SPSRT should be within 2–12 dB of the PTA (three- or four-frequency PTA) for children with normal hearing or minimal hearing loss. The four-frequency PTA was calculated based on the work of Kim et al. (2016) who looked at the agreement between PTA and SRT using several variations of the PTA to determine which might provide the best agreement with SRT for different audiometric configurations. Given the minimal hearing loss exhibited by the majority of our participants, we did not see any difference in the PTA/SPSRT comparison using a four-frequency PTA compared to the more traditional three-frequency PTA.

Table 2. Means, ranges, standard deviations, and correlation for Spanish Pediatric Speech Recognition Thresholds and pure-tone averages (PTAs) in dB HL (*N* = 24).

Measure	*M*	Range of levels	*SD*	Correlation
PTA	12	3–31	6.19	.75
SRT	2	0–20	4.86	
Difference	10			

Note. SRT = speech recognition threshold.

Our findings deviate from those reported in other studies using traditional SRT materials that suggest PTA/SRT agreement should be between 6 and 8 dB depending on the procedure used (Carhart & Porter, 1971; Hagerman, 1979; Huff & Nerbonne, 1982; Jerger, Carhart, Tillman, & Peterson, 1959). There are a few factors that likely contributed to the larger PTA/SPSRT relationship found in our data. First, it is possible that the use of a picture-pointing task, which is a closed-set task, is easier for the participant and could result in lower scores. In addition, because there were only 12 items on our picture board, this small closed set also probably contributed to our findings. There is a paucity of literature available comparing PTA and SRT using picture SRT boards, so it is difficult to make a direct comparison of our findings for a picture-pointing task. Second, Frank (1980) found that some traditional spondees (e.g., baseball and hot dog) are identified at lower intensity levels compared to other spondees (e.g., shoelace and flashlight). That is, there may be differences in the level of intelligibility between certain pictorially represented spondees in children. It is possible that some of the items in the SPSRT could have had a similar result. Future research should investigate this to ensure efficiency and precision in the measurement of the SPSRT. The normative data presented here are limited to patients with hearing within a normal range or with minimal hearing loss. These data establish the baseline relationship between PTA and SPSRT.

Although our data show a wider range of comparison between the SPSRT and PTA than the literature comparing traditional SRT and PTA, the significant positive correlations found between PTA and SPSRT for this sample suggest a strong relationship between these two measures. Additional data are currently being collected for listeners with different degrees and configurations of hearing loss to provide further information about the relationship between PTA and SPSRT.

Regional varieties of the Spanish language can be quite different from one another, specifically with regard to pronunciation and vocabulary. Thus, the outcomes from this study are limited to a population familiar with Latin American Spanish given the ethnic backgrounds of the talker on the recordings and the children tested. We recognize that, even within Latin America, there are many different dialect areas, which could have had an influence on our results. A separate recording of these stimulus items is currently being validated using a male talker with a European Spanish dialect in order to provide audiologists with additional dialectical options for their Spanish patients.

The SPSRT picture board provides ease and accuracy of scoring for the monolingual English clinician. Instead of judging the accuracy of an oral response, the audiologist can simply judge if the appropriate word/picture was identified. In addition, the picture-pointing task is also useful for nonverbal or shy children. This test could also be used for Spanish-speaking adults with limited or no English proficiency.

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Appendix A

Initial Stimulus Set of 25 Items Reduced From 100 Items Based on Familiarity Ratings

1. Agua: Water
2. Boca: Mouth
3. Cama: Bed
4. Dedo: Finger
5. Huevo: Egg
6. Jugo: Juice
7. Lápiz: Pencil
8. Leche: Milk
9. Libro: Book
10. Luna: Moon
11. Mano: Hand
12. Mesa: Table
13. Nariz: Nose
14. Niño: Boy
15. Oído: Ear
16. Ojo: Eye
17. Perro: Dog
18. Plato: Plate
19. Pollo: Chicken
20. Puerta: Door
21. Queso: Cheese
22. Ropa: Clothes
23. Silla: Chair
24. Taza: Cup
25. Uva: Grape

Appendix B

Final Stimulus Set of 12 Items on the SPSRT Picture Board

1. Silla: Chair
2. Luna: Moon
3. Puerta: Door
4. Cama: Bed
5. Leche: Milk
6. Ojo: Eye
7. Mesa: Table
8. Huevo: Egg
9. Perro: Dog
10. Uva: Grape
11. Libro: Book
12. Mano: Hand