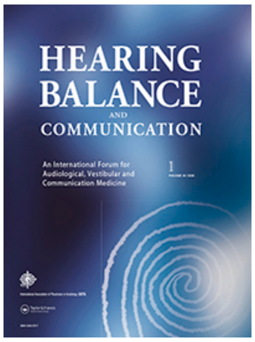

Taylor & Francis
Taylor & Francis Group

Hearing, Balance and Communication

ISSN: 2169-5717 (Print) 2169-5725 (Online) Journal homepage: https://www.tandfonline.com/loi/ihbc20

Performance of older adults with hearing loss on the staggered spondaic word test – Spanish version (SSW-SV)

Oscar M. Cañete, Viviana Almasio, Mariela C. Torrente & Suzanne C. Purdy

To cite this article: Oscar M. Cañete, Viviana Almasio, Mariela C. Torrente & Suzanne C. Purdy (2020) Performance of older adults with hearing loss on the staggered spondaic word test – Spanish version (SSW-SV), Hearing, Balance and Communication, 18:1, 66-74, DOI: 10.1080/21695717.2019.1630976

To link to this article: https://doi.org/10.1080/21695717.2019.1630976

HEARING, BALANCE AND COMMUNICATION
2020, VOL. 18, NO. 1, 66–74
https://doi.org/10.1080/21695717.2019.1630976

ORIGINAL ARTICLE

Performance of older adults with hearing loss on the staggered spondaic word test – Spanish version (SSW-SV)

Oscar M. Cañete[a,b], Viviana Almasio[c], Mariela C. Torrente[d] and Suzanne C. Purdy[a,b]

[a]Speech Science, School of Psychology, The University of Auckland, Auckland, New Zealand; [b]Eisdell Moore Centre, Research in Hearing and Balance, Auckland, New Zealand; [c]Departamento de Otoneurología, Instituto de Neurocirugía Dr Alfonso Asenjo, Santiago, Chile; [d]Servicio de Otorrinolaringología, Hospital Padre Hurtado, Santiago, Chile

ABSTRACT

Objective: The aim of the current study is to assess the performance of the staggered spondaic word Spanish Version (SSW-SV) in a group of older adults with bilateral hearing loss.

Materials and methods: A retrospective review was undertaken of medical records of adults seen at the ENT Department of the Hospital Padre Hurtado in Santiago, Chile. Ninety-six adults were included in the study ($M = 65.3$ years, SD 15.9). Pure tone audiometry and the SSW-SV were administered. All participants presented with a bilateral symmetrical sensorineural hearing loss. Uncorrected (RSSW) and corrected (CSSW) errors scores were obtained. Participants were allocated into four groups as a function of age; (a) younger (aged 20–59 years); and three older age groups in their (b) 60s; (c) 70s; and (d) 80s.

Results: There were correlations between RSSW/CSSW errors scores and hearing loss, indicating that increased errors were associated with a higher degree of hearing loss (>50 dB HL). No significant differences in performance between younger and 60s group participants were observed, whereas the older groups had more variable performance (70s and 80s groups). RSSW/CSSW total errors scores become higher with age, however significant group differences (for the competing conditions) were only observed in the older groups (70s and 80s). About 50% of the sample did not show significant order nor ear effects.

Conclusions: The SSW-SV is a useful tool to describe the dichotic listening abilities of older adults with hearing loss and can be administered to people with bilateral sensorineural hearing loss.

KEYWORDS
Auditory processing; dichotic listening; elderly; staggered spondaic word test; hearing loss

Introduction

The study of auditory processing typically includes several tests in order to assess and describe the status of the central auditory system [1]. For this purpose, several behavioral measures that examine different auditory processing abilities are available, such as, temporal processing, monaural low-redundancy speech perception, localization and lateralization, binaural function, auditory discrimination, and dichotic listening tests. Dichotic listening refers to the ability to listen to different acoustic stimuli such as speech, digits, words or sentences presented to each ear simultaneously [2].

Within the dichotic listening tests, the Dichotic Digits Test and the staggered spondaic word test (SSW) are commonly used [3,4]. The SSW test was developed in 1962 by Jack Katz, primarily as a tool to assess central auditory function in order to identify, describe, and localize central auditory disorders [5,6]. One of the advantages of the SSW, apart from using speech as stimuli, is that it is possible to correct scores to reduce the effect of a peripheral component, which would be particularly useful in studying dichotic listening abilities in adults who present a hearing loss [5,7]. However, the test has proven useful in other clinical conditions such as for children with attention-deficit hyperactivity disorder [8,9], epilepsy [10], auditory hallucinations [11], dementia [12], stuttering [13], brain lesions/neurological disorders [5,14–18], in children with learning disabilities [19], premature children [20], hearing aid users [21], immunodeficiencies [22], multiple sclerosis [23] and in the elderly population [24].

Currently, the SSW is available in different languages such as French [25], Portuguese [26], Hebrew [27], Japanese [28], Farsi [29], Australian English [30]

CONTACT Oscar M. Cañete ocan093@aucklanduni.ac.nz Speech Science, School of Psychology, The University of Auckland, Building 721.320, Tāmaki Campus, 261 Morrin road, Glen Innes, Private Bag 92019, Auckland, New Zealand

Supplemental data for this article can be accessed here.

and Spanish [31]. The Spanish version of the SSW (SV) was developed by Soto-Ramos in 1992, based on the same construction and maintaining the same characteristics of the original American English version. However, for the SSW-SV, spondaic words were replaced by disyllables which are commonly found in Spanish. The SV includes 40 items, with each item consisting of four disyllabic words. The first and the fourth words are presented monaurally, the second and the third words are presented in a temporally superimposed fashion. Thus, as is the case for all versions of the SSW, it is possible to record scores for four conditions; right ear noncompeting (RNC), right competing (RC), left competing (LEC) and left noncompeting (LNC).

There are two approaches traditionally applied to the analysis of SSW results: (1) Quantitative – obtaining raw scores (RSSW) which represent the total percentage errors, and corrected scores (CSSW) representing the percentage of errors after accounting for the peripheral component which is obtained by subtracting the word recognition scores (WRSs) for certain conditions to derive scores that correct for effects of hearing loss, for example, for a WRS of 92% (right ear) and 80% (left ear), 8% (error) should be subtracted from right ear RSSW and 20% from left ear RSSW [7,32]; and (2) Qualitative – which includes ear and order effects (EE & OE) and the number of reversal errors that people make when reporting back the words [5]. Order effects represent total errors scored on the first spondee versus the second spondee. Ear effects represent the total number of errors scored when the word sequence was started right ear first compared with left ear first [32]. EE and OE results can be categorized as high/low (H/L) or low/high (L/H). Differences $\geq$5 are considered significant. These response bias results reflect the qualitative analysis of performance on the SSW.

Dichotic tests have proven to be a useful for the study of the central auditory nervous system and central auditory processing. Deficits on dichotic listening have been reported in children with learning, language and reading problems [33,34] and in neurological conditions such as corpus callosum lesions [35].

More recently some studies have reported that dichotic listening deficits may be associated with unsuccessful binaural hearing aid use, as some individuals report doing better with one hearing aid rather than two [36,37]. It has been suggested that deficits in binaural integration and/or separations skills may lead to difficulties in capitalizing on the benefits of binaural amplification. The study of dichotic listening abilities could help provide evidence for binaural interference, which is relevant for bilateral hearing aid fittings in symmetric hearing losses [38]. A diagnosis of binaural interference, which can potentially be identified using the SSW, could be a contraindication for bilateral hearing aid fitting in people who have bilateral hearing loss evident on the audiogram. Therefore, the assessment of dichotic listening skills would be a useful tool to assist clinicians during the hearing aid fitting process, especially in cases where the amplification outcomes are not as the expected [39,40].

Although the SSW has been widely used by clinicians over many years, there is a lack of validation data for the use of the Spanish SSW-SV version, specifically for a clinical population of older adults with peripheral hearing loss. Current information available is limited to the studies of the intensity of SSW-SV performance on young normal hearing and hearing-impaired adults [41,42], auditory processing in school age children [43], case reports of auditory processing in elderly [44], and in normal hearing adults [45].

To our knowledge there is no information available about SSW-SV performance for older adults with hearing loss. The aim of the current study is to administer the SSW-SV to describe age and hearing loss effects on scores and evaluate the SSW-SV's validity in a group of older adults with bilateral hearing loss.

Methods

Participants

Ninety-six adults (47 males and 49 females) that ranged in age from 20 to 89 years ($M = 65.3$, SD 15.9) were included. Hearing loss was the primary purpose of their consultation and there was no history of previous otological conditions. All participants presented with a bilateral sensorineural symmetric hearing loss at frequencies between 0.25 and 8 kHz (no more than 15 dB HL difference between ears for each frequency), defined as having a pure tone average $\geq$25 dB HL (0.5, 1 and 2 kHz, PTA3). The difference between PTA3 and PTA5 (pure tone average for 0.5, 1, 2, 4 and 6 kHz) was also calculated, providing an indication of the audiogram slope. Participants were allocated into four groups according to their age; younger (20–59 years), 60s (60–69 years), 70s (70–79 years) and 80s (80–89 years). None reported hearing aid use previous to the assessment. A mean audiogram for all groups is shown in Figure 1.

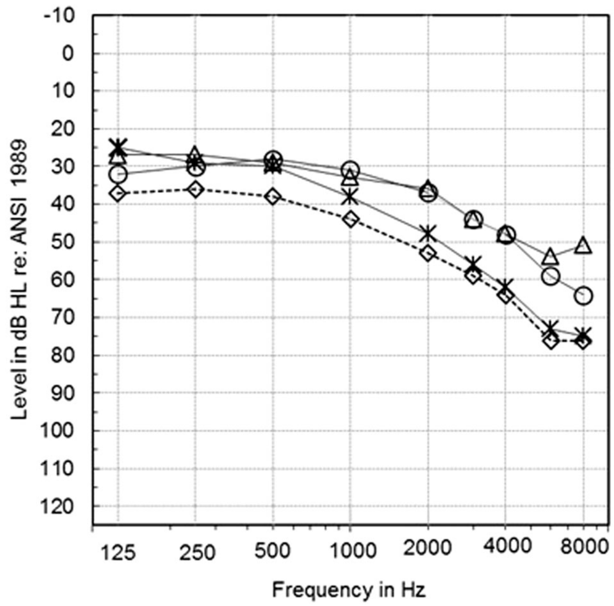

Figure 1. Mean pure-tone thresholds (composite RE/LE) by age group. Triangles represent youngers; circles represent 60s, crosses represent 70s and diamonds represent 80s groups.

All the participants were native Chilean-Spanish speakers. Participants were screened for cognitive impairment using the mini mental state examination (MMSE) [46]. None reported neurological problems at the time of the assessment. The study was approved by the local Ethics committee of the Hospital Padre Hurtado.

The Shapiro–Wilk test of normality was applied to all data, and nonparametric tests (Kruskal–Wallis *H*-test) were used to compare groups and conditions when assumptions of normality were not met. A Bonferroni correction was used to adjust the alpha level of 0.05 to correct for the number of post-hoc paired comparisons. Spearman rank-order correlations were calculated to explore the relationships between SSW scores and PTA5, and SSW scores and age. Also, one-way ANOVA analysis was conducted to determine whether there were statistically significant differences across groups in the pure tone threshold slope.

Peripheral hearing assessment

Pure tone thresholds were measured at octave frequencies 0.125–8 kHz using an Orbiter 922 audiometer in a sound booth with TDH39 earphones. Middle ear status was checked by measuring 226 Hz tympanograms and ipsilateral acoustic reflexes at 0.5, 1, 2 and 4 kHz using a Madsen ZODIAC 901 admittance meter. WRSs in each ear were obtained using recorded monosyllabic words (25-word list) [47] presented through the audiometer at 30 or 40 dB SL (Sensation level) above the three frequency average for 0.5, 1 and 2 kHz (PTA3). The difference in WRS between ears were ≤20%.

SSW test

The SSW was administered after the pure tone and immittance audiometry. The SV, available from AUDITEC (St. Louis) and developed by Soto-Ramos et al. [31], was used. Presentation level was selected at 30 or 40 dB SL above the individual's PTA3 [42,48]. Stimuli presentation started with the right ear first [32,42]. The test was scored as per administration guidelines to obtain RSSW, CSSW, EE and EO scores. Note that presentation level for WRS and SSW were the same for each subject. More information about correction for hearing loss is presented in Supplementary online material.

Results

Peripheral hearing assessment

As seen in Table 1, pure tone average (PTA3/PTA5) increased with age ($r_s(94) = 0.556$, $p < .001$, and $r_s(94) = 0.461$, $p < .001$, respectively), as expected. Since there were no differences greater than 10 dB between ears for each frequency, composite pure tone thresholds scores were included in the subsequent analyses.

In order to explore possible differences across groups in the pure tone threshold slope, the differences between PTA3 and PTA5 were also compared. There was a statistically significant difference between groups as determined by one-way ANOVA ($F_{(3,92)} = 3.706$, $p = 0.014$, $\eta^2 = 0.10$). Post hoc tests revealed that the 70–79 year group had significantly higher PTA3-5 differences than the 20–59 years group ($p = .010$), consistent with the increasing gap in the audiogram for the youngest versus the oldest groups evident in the high frequencies (Figure 1).

Effects of hearing loss

A Spearman's rank-order correlation was run to determine the relationship between overall RSSW/CSSW errors and PTA5 (which is more representative of the changing hearing loss configuration across age groups). There was a significant moderate association for RSSW ($r_s(94) = 0.638$, $p < .001$), and low

Table 1. Distribution of subjects by age group ($N = 96$).

Group (years)	N	Mean years (SD)	Pure tone average (SD) PTA3*	PTA5**	Difference PTA PTA3–PTA5	Word recognition scores % (SD)±
20–59	26	44.7 (11.9)	32.3 (13.4)	39.9 (13.7)	−7.3 (6.1)	92.5 (5.8)
60–69	24	65.1 (2.9)	31.8 (13.2)	40.5 (13.8)	−8.6 (4.3)	90.4 (7.4)
70–79	28	73.9 (2.2)	38.4 (14.8)	50.0 (14.0)	−11.5 (4.6)	89.7 (7.3)
80¯ 89	18	83.4 (2.5)	44.9 (9.4)	54.9 (10.3)	−9.9 (3.4)	76.0 (12.3)
Total	96	65.3 (15.9)	36.4 (13.9)	45.8 (14.4)	−9.4 (5.1)	88.1 (10.)

PTA: pure tone average.
*0.5, 1 and 2 kHz.
**0.5, 1, 2, 4, 6 kHz.
±Composite scores (RE/LE).

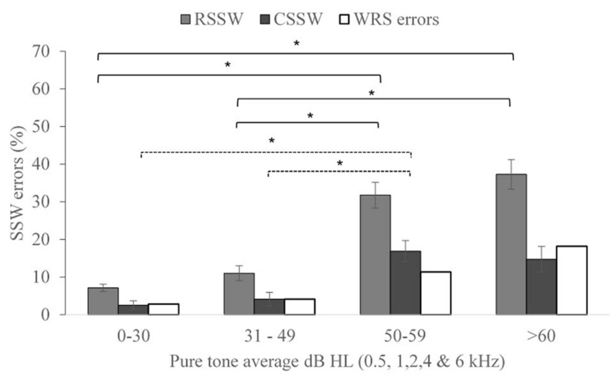

Figure 2. RSSW, CSSW and WRS errors as function of hearing loss (re: five-frequency PTA). [*] significant difference after Bonferroni correction for multiple comparisons.

association for CSSW ($r_s(94) = 0.332$, $p = .011$), with PTA5, as errors become higher for greater hearing losses.

Participants were allocated into four categories according PTA5 (0–30, 31–49, 50–59 and >60 dB HL) (Figure 2). A Kruskal–Wallis H-test showed that there was a statistically significant difference in RSSW errors as a function of hearing loss categories ($\chi^2(3) = 41.684$, $p < .001$), however, Bonferroni-adjusted pairwise comparisons revealed no significant differences for PTA5 < 50 dB HL (no differences between 0–30 and 31–49 dB HL groups). A Kruskal–Wallis H test also showed that CSSW errors scores differed with severity of hearing loss ($\chi^2(3) = 15.789$, $p = .001$). Consistent with the findings for the raw scores, no significant differences were observed for CSSW error scores for PTA5 < 50 dB HL. Thus, RSSW and CSSW scores did not differ between normal hearing and mild hearing loss groups.

Effects of age

As seen in Table 2, regardless of age group, the left ear competing (LC) condition had the highest errors followed by left non-competing condition (LNC) for both RSSW and CSSW scores.

A Spearman's rank-order correlation was run to determine the relationship between SSW errors scores and age. As, expected there was a statistically significant positive correlation between RSSW and CSSW overall errors scores and age ($r_s(94) = 0.552$, $p < .001$, and $r_s(94) = 0.393$, $p < .001$, respectively).

A Kruskal–Wallis H-test showed that there was a statistically significant difference for RSSW and CSSW total error scores across age groups ($\chi^2(3) = 24.363$, $p < .001$, and $\chi^2(3) = 15.944$, $p = .001$, respectively). Pairwise comparisons for RSSW scores revealed significant differences between younger and 70s groups ($\chi^2(3) = -21.933$, $p = .023$), younger and 80s groups ($\chi^2(3) = -38.252$, $p < .001$), and 60s and 80s groups ($\chi^2(3) = -32.299$, $p = .001$), as RSSW errors increased with age (Figure 3).

CSSW total error scores, which correct for hearing loss effects on speech discrimination scores, differed only between the younger and 70s groups ($\chi^2(3) = -26.032$, $p = .004$), and 60s and 70s groups ($\chi^2(3) = -21.360$, $p = .035$) (Figure 4).

Effects of test ear

Overall RSSW and CSSW error scores between RC and LC conditions showed significant differences; Wilcoxon signed ranks test revealed that left ear errors scores were significantly higher than right ear errors ($Z = -5.176$, $p < .001$, and $Z = -5.033$, $p < .001$, respectively). Significant RC versus LC differences were obtained within each age group for corrected and uncorrected scores, except for the younger group ($Z = -1.412$, $p = .158$ and $Z = -1.341$, $p = .180$, respectively)

Response bias

As seen in Table 3, over 40% of the sample presented with no significant order or ear effects (difference ≤5), except for the ear effect in the older group. The most common EE category was L/H, indicating higher score errors for left ear presentations across all

Table 2. RSSW and CSSW error scores for each listening conditions by age group.

Group (years)	RNC Mean (SD)	RNC Median	RNC IQR	RC Mean (SD)	RC Median	RC IQR	LC Mean (SD)	LC Median	LC IQR	LNC Mean (SD)	LNC Median	LNC IQR
RSSW												
20–59	5.8 (6.1)	3.8	7.5	11.3 (11.9)	7.5	15.6	16.2 (15.7)	13.8	16.2	9.8 (10.4)	7.5	10.0
60–69	10.3 (17.7)	2.5	13.7	14.4 (19.6)	5.0	14.3	23.3 (19.6)	18.8	21.8	15.5 (17.5)	10.0	19.3
70–79	9.9 (10.9)	6.3	17.5	19.1 (14.6)	13.8	21.8	46.0 (33.4)	42.5	61.2	27.3 (29.5)	12.5	44.3
80–89	21.4 (16.0)	20.0	25.6	31.8 (23.3)	27.5	26.8	56.1 (30.8)	66.3	46.2	41.4 (30.5)	36.3	54.3
Overall	11.0 (13.9)	6.3	15.0	18.2 (18.4)	10.0	20.0	34.1 (29.9)	22.5	46.8	22.3 (25.5)	10.0	30.0
CSSW												
20–59	−1.7 (7.1)	−1.0	7.5	3.8 (12.3)	1.5	9.5	8.7 (15.3)	4.0	11.0	2.4 (10.0)	−0.5	8.0
60–69	0.1 (16.0)	−4.0	12.5	4.2 (17.2)	−2.2	13.2	14.3 (16.2)	11.5	22.5	6.5 (13.9)	2.7	14.0
70-–79	0.9 (8.1)	−1.5	10.7	10.1 (9.2)	10.5	13.7	34.5 (29.2)	31.5	48.0	15.8 (24.1)	4.7	26.0
80-–89	−1.5 (13.7)	−2.5	10.5	8.9 (10.2)	2.5	18.5	31.0 (25.1)	30.0	24.5	16.2 (27.8)	10.5	34.0
Overall	−0.5 (11.4)	−2.3	9.5	6.7 (14.8)	2.8	15.0	21.8 (24.6)	13.5	31.5	10.0 (20.4)	2.3	20.5

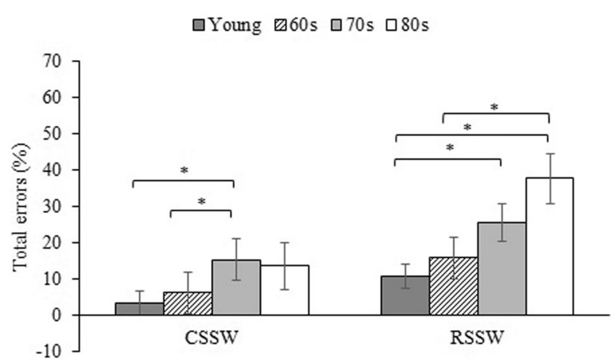

Figure 3. SSW raw and corrected total scores by group. Bar represent the 95% confidence interval for the mean. [*] after Bonferroni correction for multiple comparisons.

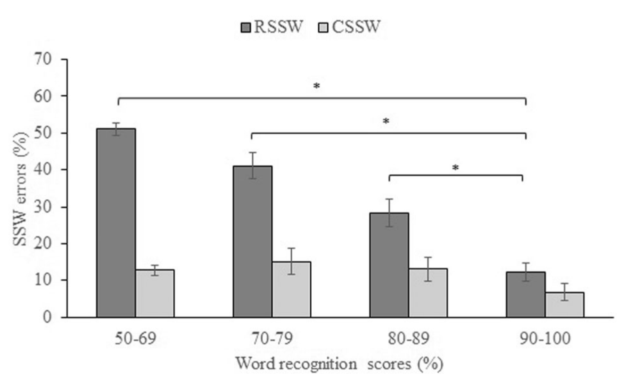

Figure 4. RSSW and CSSW error scores as a function of WRS. Bar represent the 95% confidence interval for the mean. [*] significant difference after Bonferroni correction for multiple comparisons.

Table 3. Frequency (%) for order and ear effect by age group.

Group	*N*	Order effect NS	Order effect Low/high	Order effect High/low	Ear effect (REF vs. LEF) NS	Ear effect Low/high	Ear effect High/low
20–59	26	57.7 (15)	15.3 (4)	26.9 (7)	57.7 (15)	26.9 (7)	15.4 (4)
60–69	24	54.2 (15)	16.6 (4)	29.1 (7)	62.5 (15)	25.0 (6)	12.5 (3)
70–79	28	57.1 (13)	25.0 (7)	17.9 (5)	42.9 (12)	46.4 (13)	10.7 (3)
80–89	18	44.4 (16)	27.8 (5)	27.8 (5)	38.9 (7)	44.4 (8)	16.7 (3)

NS: no significant difference, ≤5.

groups. For OE, the younger groups generally showed higher score errors for the first two words (H/L), whereas this is reversed to a low/high pattern in the older groups.

Qualitative data on the number of reversals were not collected consistently and hence are not unavailable for analysis.

Discussion

Overall the results show the expected effects of peripheral hearing loss on RSSW and CSSW results. Consistent with previous reports [7,49] hearing loss (e.g. five frequency PTA5) less than 50 dB HL did not affect RSSW or CSSW scores. Thus, mild symmetrical bilateral hearing loss at any age is unlikely to have a significant impact on scores, supporting the use of the SSW as a diagnostic test for dichotic listening that does not require normal pure tone thresholds for clinical use.

Both RSSW and CSSW scores were affected by greater degrees of hearing loss, however, in our sample this is likely to reflect the association between greater hearing loss and older age. As expected [24,49], our results indicate increments in RSSW and CSSW error scores with age. CSSW total error scores, which correct for hearing loss effects on speech discrimination scores, differed only between the younger and 70s groups and between the 60s and 70s age groups. This is somewhat consistent with published SSW results for older adults which show greater evidence for ageing effects of scores for people aged in their 70s. For example, in an early SSW study involving a sample of 156 adults with bilateral symmetric sensorineural hearing loss ($M = 44.7$ years, SD = 11.0), categorized into age groups similar to our study, no significant differences between the younger and 60s groups for CSSW total scores were reported [50]. However, individuals in the 70s group showed more variable performance when hearing loss exceeded 40 dB HL, and individuals in the 80s group presented with the highest number of errors and the greatest degree of hearing loss. Variability in performance for people aged over 70 years, (especially for left ear presentations), could reflect central auditory effects, but also could reflect cognitive changes associated with ageing. In the current study, this was controlled for to some extent, as participants were included only if they passed the MMSE evaluation. This differed from Arnst et al.'s [50] sample where participants' cognitive status was not assessed. In both studies, however, age effects on SSW scores (compared with younger adults in the study) became evident for people in their 70s, and not for people aged in their 60s. Aging effects on auditory abilities reflect and interaction between peripheral and central auditory and cognitive factors [51,52]. Cognitive screening in the present study was carried out using the MMSE which is sensitive to more severe forms of cognitive impairment [53,54], therefore it is not possible to rule out the influence of other less severe forms of cognitive impairment in our participants. Other screening tools such as the Montreal Cognitive Assessment may be more sensitive to mild cognitive impartment [53,55] and could be useful when considering the influence of cognitive status on dichotic listening performance [56].

Age effects on dichotic listening have been commonly evaluated by examining changes in the right ear advantage. These changes in right versus left ear performance are consistent with the decrease in interhemispheric transference at the level of the corpus callosum as a result of anatomical and functional changes that take place within the auditory system due to aging [57,58]. It has been reported that left ear suppression (larger right ear advantage) seen in dichotic listening tests in some elderly may lead to binaural processing difficulties [59] and hence these ear differences can have functional consequences for successful hearing rehabilitation with hearing aids, for example. Wilson and Jaffe [60] reported dichotic digits test performance in older adults with mild- to moderate hearing loss ($n = 20$). Their sample had larger right ear advantages compared to younger normal hearing adults ($n = 20$). Similarly, in the current study we observed that differences between right and left competing conditions were not significant in the younger group but were in the older groups. There is evidence of an increase of left ear errors with age, and this increase cannot be fully explained by the severity of the hearing loss.

Significant ear differences between competing conditions (RC and LC) were observed mainly in the older participants. In line with previous studies, where older adults presented with larger error scores for left ear presentations in dichotic listening tasks [51,59,61,62], our sample also demonstrated increased left ear disadvantage with age. A right-ear advantage is expected in older adults with hearing loss due to these left-ear deficits. However, in the current study, this is also associated with higher variability (larger standard deviations) in performance for the oldest age group.

Poor dichotic listening performance may lead to important perceptual deficits for older adults. Clinically, older adults with hearing loss and binaural interference [40] would present with poorer binaural/bilateral speech recognition scores (i.e. unaided or aided conditions) compared to scores for monaural/unilateral stimulus presentation, beyond what can be explained by the hearing thresholds. More research is needed to fully establish the impact of this on hearing aid outcomes and the experience of binaural interference in older adults [40].

The use of dichotic listening tests such as the SSW-SV would help clinicians by identifying and describing the changes in dichotic listening due to aging (e.g. deficits in integration and/or separation), changes which may contribute to poor outcomes with amplification. The prevalence of binaural interference has not been established yet and the inclusion of dichotic testing in the clinical test battery could provide useful information about the consequences of aging for auditory processing in older individuals with hearing loss by revealing ear differences in dichotic listening that could influence hearing aid outcomes.

The response bias analysis for the ear effect indicated that about half of the individual participants had no significant differences between ears. For the group who presented significant EE differences, about 74% had smaller errors scores for the right ear compare to left ear (low/high pattern). This result is generally consistent with earlier reports that the most frequent ear effect pattern was low/high, with about 30% of the cases labeled as having significant EE differences [50]. In line with Arnst et al.'s work [50], ear differences reported here cannot be solely explained by peripheral sensitivity as all the participants had symmetrical hearing loss.

The examination of order effects showed that about the 60% of the total sample did not present with significant differences between the first and second, or the third and fourth words. Within the group who presented with significant differences, there were no clear predominant patterns (low/high or high/low), which was also seen in Arnst et al.'s study. The developers of the SSW have proposed that this response bias analysis can be useful in localizing lesions within the central auditory system [5,6], however, its use may be limited by the presence of a peripheral hearing loss as this condition can produce responses biases in itself [7,32].

Limitations and future research

Overall, participants given the SSW-SV in the current study displayed similar performances to those given the English version of the test in earlier studies. The Spanish version seems to be sensitive to changes in auditory processing in the elderly population [7,49].

Currently there is one SSW list available in Spanish, thus the development of more lists is needed. The use of different speech material to get word recognition may have a differential effect on the peripheral correction for the SSW scores, thus this area should be investigated to improve the SSW's diagnostic characteristics.

There is some evidence of the psychometric functions of Spanish disyllables being similar to English monosyllables (NU-6, W-22) [63], which are commonly used to get CSSW scores in the English version of the test. Unfortunately, there is no information available about the psychometric function of the Spanish monosyllabic word lists used here to obtain WRSs.

Before the use of SSW-SV with clinical populations, it is important to consider current evidence which indicate that normal hearing Spanish speaker's performance on word recognition tests may be affected by their native dialect [64], as phonetic differences might account for differences in perception. Therefore, it would be appropriate and necessary to obtain local normative data in normal and hearing-impaired clients.

A larger sample is needed to control for factors such as gender and handedness, which might have an effect on dichotic listening performance [65]. Our sample only included native Spanish (Chilean dialect) monolingual speakers, thus the performance of bilinguals or other speakers of other Spanish dialects must be investigated before extending its clinical use in this population. Factors such as differences in hearing threshold slopes across age groups could be considered in future studies to minimize possible peripheral factors over the test performance.

Conclusions

Staggered spondaic word errors scores increased with age. There were no significant differences in performance between younger and 60s group participants, but older groups presented a more variable performance (70s and 80s groups). Correction factors for hearing loss in the SV would minimize the effect of peripheral distortion, however for losses above 50 dB HL caution must be taken when analyzing the data. SSW error scores increase as severity of hearing loss increase (PTA5 > 50 dB HL). About 50% of the sample did not present with significant order neither ear effects. This study provides useful insights into new research areas using the SSW-SV, and contributes to the extension of its use within the Spanish speaking population.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Oscar M. Cañete http://orcid.org/0000-0002-2622-5086
Mariela C. Torrente http://orcid.org/0000-0002-3151-9142
Suzanne C. Purdy http://orcid.org/0000-0001-9978-8173

References

[1] American Academy of Audiology. Clinical Practice Guidelines: Diagnosis, Treatment and Management of Children and Adults with Central Auditory Processing Disorder [Internet]. Available from: http://audiology-web.s3.amazonaws.com/migrated/CAPD%20Guidelines%208-2010.pdf_539952af956c79.73897613.pdf

[2] Bellis TJ, Bellis JD. Central auditory processing disorders in children and adults. Handb Clin Neurol. 2015;129:537–556.

[3] American Speech-Language-Hearing Association. (Central) auditory processing disorders [Internet]. ASHA. Available from: www.asha.org/policy

[4] Emanuel DC, Ficca KN, Korczak P. Survey of the diagnosis and management of auditory processing disorder.(research article)(report). Am J Audiol. 2011;20:48.

[5] Katz J, Smith PS. The staggered spondaic word test. A ten-minute look at the central nervous system through the ears. Ann N Y Acad Sci. 1991;620: 233–251.

[6] Katz J. The use of staggered spondaic words for assessing the integrity of the central auditory nervous-system. J Aud Res. 1962;2:327–337.
[7] Arnst DJ, Doyle PC. Verification of the corrected staggered spondaic word (SSW) score in adults with cochlear hearing loss. Ear Hear. 1983;4:243
[8] Riccio CA, Hynd GW, Cohen MJ, et al. The staggered spondaic word TestPerformance of children with attention-deficit hyperactivity disorder. Am J Audiol. 1996;5:55–62.
[9] Tillery KL, Katz J, Keller WD. Effects of methylphenidate (Ritalin) on auditory performance in children with attention and auditory processing disorders. J Speech Lang Hear Res. 2000;43:893–901.
[10] Ortiz K, Pereira L, Borges A, et al. Staggered spondaic word test in epileptic patients. Sao Paulo Med J. 2002;120:185–188.
[11] McKay CM, Headlam DM, Copolov DL. Central auditory processing in patients with auditory hallucinations. Am J Psychiatry. 2000;157:759–766.
[12] Grady CL, Grimes AM, Patronas N, et al. Divided attention, as measured by dichotic speech performance, in dementia of the Alzheimer type. Arch Neurol. 1989;46:317–320.
[13] Hall JW, Jerger J. Central auditory function in stutterers. J Speech Hear Res. 1978;21:324–337.
[14] Da Silva JB, De Almeida C, Sens PM, et al. Dichotic listening test in patients with chronic cerebellar disease. Am J Otolaryngol. 2012;33:326–331.
[15] Musiek FE, Wilson DH. SSW and dichotic digit results pre- and post-commissurotomy: a case report . J Speech Hear Disord. 1979;44:528–533.
[16] Folmer RL, Vachhani JJ, Theodoroff SM, et al. Auditory processing abilities of Parkinson's disease patients. Biomed Res Int. 2017;2017:1.
[17] Zeigelboim BS, de Carvalho HAS, Teive HAG, et al. Central auditory processing in patients with spinocerebellar ataxia. Hear Res. 2015;327:235–244.
[18] Turgeon C, Champoux F, Lepore F, et al. Auditory processing after sport-related concussions. Ear Hear. 2011;32:667–670.
[19] Stubblefield JH, Young CE. Central auditory dysfunction in learning disabled children. J Learn Disabil. 1975;8:89–94.
[20] Amin S, Orlando M, Monczynski C, et al. Central auditory processing disorder profile in premature and term infants. Am J Perinatol. 2015;32:399–404.
[21] Lessa AH, Hennig TR, Costa MJ, et al. Results of auditory rehabilitation in elderly users of hearing aids evaluated by a dichotic test. CoDAS. 2013;25: 169–175.
[22] Romero ACL, Alfaya LM, Gonales AS, et al. Auditory alterations in children infected by human immunodeficiency virus verified through auditory processing test. Int Arch Otorhinolaryngol. 2017;21: 86–91.
[23] Lewis MS, Wilmington D, Hutter M, et al. Preliminary identification of central auditory processing screening tests for individuals with multiple sclerosis. Semin Hear. 2012;33:261–273.
[24] Cooper JJ, Gates GA. Hearing in the elderly – the Framingham cohort, 1983–1985: part II. prevalence of central auditory processing disorders. Ear Hear. 1991;12:304–311.
[25] Rudmin F, Normandin N. Experimental dichotic tests in French modeled on SSW design. Hum Commun Canada. 1983;7:348–360.
[26] Borges AA. Do teste SSW para a língua portuguesa: Nota preliminar. Acta Awho. 1986;5:38–40.
[27] Keydar B, Katz J. The Hebrew version of the staggered spondaic word (SSW) test. J Aud Res. 1976;16: 135–142.
[28] Rudmin FW. The development of a Japanese SSW test. Audiol Japan. 1979;22:36–40.
[29] Hajiabolhassan F, Lotfi Y, Azordegan F. Introducing and evaluating a Farsi-language version of the staggered spondaic word test in normal hearing subject. Bimonthly Audiol-Tehran Univ Med Sci. 2006;15: 39–46.
[30] Golding M, Lilly DJ, Lay JW. A staggered spondaic word (SSW) test for Australian use. Austr J Audiol. 1996;18:81–88.
[31] Soto-Ramos H, Windham RA, Katz J. Introducing a Spanish-language version of the staggered spondaic word test. Hear J. 1992;45:39–43.
[32] Katz J. Ivey R. Spondaic procedures in central testing In: Katz J, editor. Handbook of clinical audiology. 4th ed. United States: Williams & Wilkins Baltimore, London; 1994. p. 239–55.
[33] Moncrieff D, Jorgensen L, Ortmann A. Chapter 11 – psychophysical auditory tests In: Celesia GG, editor. Handbook of clinical neurophysiology. Amsterdam: Elsevier BV; 2013. p. 217–234.
[34] Purdy SC, Kelly AS, Davies MG. Auditory brainstem response, middle latency response, and late cortical evoked potentials in children with learning disabilities. J Am Acad Audiol. 2002;13:367–382.
[35] Musiek FE, Chermak GD. Chapter 18 – psychophysical and behavioral peripheral and central auditory tests In: Aminoff MJ, Boller F, Swaab DF, editors. Handbook of clinical neurology. Amsterdam: Elsevier; 2015. p. 313–332.
[36] Chmiel R, Jerger J. Hearing aid use, central auditory disorder, and hearing handicap in elderly persons. J Am Acad Audiol. 1996;7:190–202.
[37] Chmiel R, Jerger J, Murphy E, et al. Unsuccessful use of binaural amplification by an elderly person. J Am Acad Audiol. 1997;8:1–10.
[38] Mussoi BS, Bentler RA. Binaural interference and the effects of age and hearing loss. J Am Acad Audiol. 2017;28:5–13.
[39] Armero O, Cerkoney A. Auditory processing assessment model for older patients. Hear J. 2018;71: 38–40.
[40] Jerger J, Silverman CA. Binaural interference: a guide for audiologists. 1st ed. San Diego (CA): Plural Publishing. 2018. p. 124.
[41] Cañete OM. Performance of normal hearing adults on the SSW Spanish language version: Intensity effects. SSW Rep. 2008;30:13–18.
[42] Soto C, Estay G, Aladro S, et al. Rendimiento de la prueba SSW version en español: Efectos de intensidad en adultos con hipoacusia sensorioneural simétrica. Rev Chil Tecnol Méd. 2013;33:1739–1744.

[43] Farfán C SC. Correlación de los resultados de la prueba VE-SSW con el rendimiento escolar en niños de tercer año de enseñanza básica del liceo miguel rafael prado de la comuna de independencia, santiago. chile. Rev Chil Tecnol Méd. 2011;31: 1621–1628.
[44] Cañete O. Procesamiento auditivo en adultos mayores: Reporte de casos. Rev Otorrinolaringol Cir Cabeza Cuello. 2010;70:57–64.
[45] Fuente A, McPherson B. Auditory processing tests for Spanish-speaking adults: an initial study. Int J Audiol. 2006;45:645–659.
[46] Quiroga P, Albala C, Klaasen G. Validation of a screening test for age associated cognitive impairment, in Chile. Rev Med Chil. 2004;132:467–478.
[47] Rosenblut B, Cruz JP. Listas de palabras en español para pruebas de discrimination. Rev Otorinolaringol. 1962;22:37–49.
[48] Flynn AP, Danhauer LJ, Gerber ES, et al. SSW test performance-intensity functions for hearing-impaired adults. Ear Hear. 1984;5:346–348.
[49] Arnst DJ. Staggered spondaic word test performance in a group of older adults: a preliminary report. Ear Hear. 1982;3:118–123.
[50] Arnst DJ, Arnst J, Katz J. SSW test results with peripheral hearing loss. In: Central auditory assessment: the SSW test: development and clinical use. 1982, 287–293.
[51] Martin JS, Jerger JF. Some effects of aging on central auditory processing. J Rehabil Res Dev. 2005;42:25.
[52] Humes LE. Understanding the speech- understanding problems of older adults (research forum)(report). Am J Audiol. 2013;22:303.
[53] Arevalo-Rodriguez I, Smailagic N, Roqué i Figuls M, et al. Mini-Mental state examination (MMSE) for the detection of Alzheimer's disease and other dementias in people with mild cognitive impairment (MCI). Cochrane Database of Systematic Reviews. 2015;(3):CD010783.
[54] Dong Y, Lee WY, Basri NA, et al. The Montreal cognitive assessment is superior to the Mini–Mental state examination in detecting patients at higher risk of dementia. Int Psychogeriatr. 2012;24:1749–1755.
[55] Larner AJ. Screening utility of the Montreal cognitive assessment (MoCA): In place of–or as well as–the MMSE? Int Psychogeriatr. 2012;24:391–396.
[56] Murphy CFB, Rabelo CM, Silagi ML, et al. Auditory processing performance of the middle-aged and elderly: auditory or cognitive decline? J Am Acad Audiol. 2018;29:5–14.
[57] Jeeves MA, Moes P. Interhemispheric transfer time differences related to aging and gender. Neuropsychologia. 1996;34:627–636.
[58] Jerger J, Chmiel R, Wilson N, et al. Hearing impairment in older adults: new concepts. J Am Geriatr Soc. 1995;43:928–935.
[59] Jerger J, Chmiel R, Allen J, et al. Effects of age and gender on dichotic sentence identification. Ear Hear. 1994;15:274–286.
[60] Wilson RH, Jaffe MS. Interactions of age, ear, and stimulus complexity on dichotic digit recognition. J Am Acad Audiol. 1996;7:358–364.
[61] Roup CM, Wiley TL, Wilson RH. Dichotic word recognition in young and older adults. (Report). J Am Acad Audiol. 2006;17:230.
[62] Kam ACS, Keith RW. Aging effect on dichotic listening of Cantonese. Int J Audiol. 2010;49:651–656.
[63] Weisleder RP, Hodgson RW. Evaluation of four Spanish word-recognition-ability lists. Ear Hear. 1989;10:387–393.
[64] Shi L, Canizales LA. Dialectal effects on a clinical Spanish word recognition test. Am J Audiol. 2013; 22:74–83.
[65] Hugdahl K. Brain lateralization: Dichotic studies. Neuroscience. 1992;2:23–28.