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# Listening in Spatialized Noise – Universal Test (LiSN-U) Test-Retest Reliability Study

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Keywords: spatial processing disorder, central auditory processing disorders, test-retest reliability, speech perception

# Listening in Spatialized Noise – Universal Test (LiSN-U) Test-Retest Reliability Study

Objective: To assess test-retest reliability of the Listening in Spatialized Noise – Universal test (LiSN-U).

Design: Test-retest reliability study. Participants completed the LiSN-U twice, four to eight weeks apart.

Study Sample: Test-retest reliability was analysed for 23 adults and 109 children.

Results: ANOVA showed significant group average score improvement on LiSN-U spatially-separated and co-located conditions on retest (by 1.3 and 0.9 dB respectively), but not on the difference between them (spatial advantage). Critical difference scores for children were -3.6 dB for the spatially-separated condition, -5.8 dB for the co-located condition, and 5.5 dB for spatial advantage. Critical difference scores for adults were -2.0 dB for the spatially-separated condition, -4.9 dB for the co-located condition, and 5.4 dB for spatial advantage. A correlation analysis was run to determine the relationship between test and retest speech reception thresholds. The correlation was $r = 0.63$, $p < 0.001$ for the spatially-separated condition, $r = 0.50$, $p < 0.001$ for the co-located condition, and $r = 0.37$, $p < 0.001$ for the spatial advantage measure.

Conclusions: The LiSN-U, which is potentially useable for speakers of any language, shows mean test-retest difference and test-retest reliability comparable to other tests that have proven useful in clinical practice.

## Introduction

A person’s speech perception ability is affected by their native language. While monolingual speakers perceive speech equally well to bilingual speakers in quiet conditions, bilingual speakers have greater speech perception difficulties at poor SNRs (Kilman, Zekveld, Hällgren, & Rönnberg, 2014; Krizman, Bradlow, Lam, & Kraus, 2016; Rogers, Lister, Febo, Besing, & Abrams, 2006; Schafer et al., 2018; Tabri, Chacra, & Pring, 2011). The Listening in Spatialized Noise – Universal test (LiSN-U) was developed as a language-independent version of the Listening in Spatialized Noise – Sentences test LiSN-S to detect spatial processing disorder (SPD) in children who have language backgrounds other than English. SPD is a specific type of central auditory processing disorder (CAPD) where children have difficulty using the interaural time and intensity differences of auditory signals coming from various directions to differentiate a target signal from competing signals (Cameron & Dillon, 2007a, 2008, 2011; Cameron, Dillon, & Newall, 2005, 2006; Cameron, Glyde, & Dillon, 2012; Glyde, Cameron, Dillon, Hickson, & Seeto, 2013; Glyde, Hickson, Cameron, & Dillon, 2011). As a result of the disorder, these children need a better signal-to-noise ratio (SNR) to achieve the same speech reception threshold (SRT) as children without the disorder.

The LiSN-U iPad app simulates a three-dimensional auditory environment presented over headphones using head-related transfer functions. The target and distracter stimuli are consonant-vowel-consonant-vowel (CVCV) pseudo-words using phonemes that are common to most languages. The development of the LiSN-U, as well as results of a stimulus intelligibility study and normative data study, is described in detail in Cameron, Mealings, Chong-White, Young, and Dillon (2020). The test consists of a spatially-separated condition and a co-located condition. In both conditions the target speech sounds like it is coming from the front. In the spatially-separated condition the distractors sound like they are coming from either side of the listener which allows the listener to use spatial cues to identify the target word. The co-located condition presents the distractors from the front (i.e. the same position as the target) so the listener is unable to use spatial cues to identify the target.

The SRTs from the two conditions are then compared to give a spatial advantage score. Using a comparative score minimizes variation arising from individual differences in cognitive and phonological abilities. As these abilities will affect both the spatially-separated and co-located conditions they will have little or no effect on the spatial advantage difference measure. A listener with SPD would be expected to show below-normal performance on the spatially-separated condition and the spatial advantage score, but performance within normal limits on the co-located condition. Cameron et al. (2020) found significant improvements in the SRTs as the participant's age increased from five to 12 years and to adult for the spatially-separated and co-located conditions, as well as the spatial advantage measure.

A clinical test cannot be deemed useful, however, unless it is found to be sufficiently reliable. Reliability refers to the extent to which test results are repeatable and give similar results on the same participants at different time points. Test reliability is important to consider when choosing test materials and interpreting test results (Cacace & McFarland, 1998). If a test has poor reliability it is difficult to determine whether or not a participant falls outside the normal range, and whether a remediation program has been successful. Several studies have assessed test-retest reliability of speech intelligibility tests. The average difference in SRT between test and retest of the Bamford-Kowal-Bench (BKB) sentences test in seven children was -1.29 dB with a SD of 1.75 dB (Bamford & Wilson, 1979). The overall test-retest median SRT measurement difference for the Oldenburg sentences test using different presentation levels and noise types was 0.67 dB for 10 participants with normal hearing and 0.23 dB for 10 participants with hearing impairment (Wagener & Brand, 2005). The test-retest SRT improvement was 0.13 dB in a speech-in-noise test conducted by Hagerman and Kinnefors (1995) with 10 normal hearing participants. Bentler (2000), investigated test-retest reliability in 20 adults on the speech in noise test (SIN). The reliability coefficient was 0.80 averaged across SNR and presentation levels for normal hearers. A critical difference of 2.6 dB was calculated for SRTs at a presentation level of 53 dB SPL and 2.4 dB at a presentation level of 83 dB SPL across equivalent lists.

Test-retest reliability was also assessed on the LiSN-S (see Cameron & Dillon, 2007b). Mean changes in performance on retest on the different LiSN-S measures were 0.1-1.1 dB across the four subtests. Reliability as measured by Pearson product-moment correlation analyses, on a normative population with no spatial processing problems, were all significant with *r* ranging from 0.3-0.8. Test score critical differences ranged from 2.5-4.4 dB improvements on the different measures. As a result of these small test-retest changes in performance and the significant correlations, it was concluded that the LiSN-S is suitable for monitoring a listener's spatial processing abilities over time. The calculation of critical difference scores makes it possible to determine whether a change in test score after remediation can be safely attributed to the remediation, or are within the range that can occur due to the combined effects of practice and random measurement error (Cameron & Dillon, 2007b). The aim of this study was to assess the test-retest reliability of the LiSN-U in a typically-developing, normal hearing population of English-speaking children and adults and calculate critical difference scores.

## Method

The methodology for this study described below was identical to the methodology used in the LiSN-U normative data study described in Cameron et al. (2020).

### *Participants*

The participants were a subset (determined by availability) of 23 adults aged 19 yr 5 m to 56 yr 5 m (mean 30 yr 1 m) and 109 children aged 5 yr 0 m to 12 yr 0 m (mean 8 yr 6 m) from the Cameron et al. (2020) study. There were 13 female and 10 male adults and 56 female and 53 male children. Consent was given for all participants who took part in the study. Participants had no hearing loss screened down to 20 dB HL at all octave frequencies from 500 to 8000 Hz measured in both ears separately. Children were tested in a quiet room at their primary school. Adults were tested in an audiometric test booth at the National Acoustic Laboratories.

### *Procedure*

The LiSN-U was presented using an Apple iPad Air 2 running iOS 10.2.1 (California, USA) and Sennheiser HD 200 Pro circumaural headphones (Hanover, Germany). The volume level of the iPad was automatically set by the LiSN-U software to maximum level in order to calibrate the audio signals. The participant's task was to repeat back target CVCV pseudo-words (e.g. /tigu/) presented in background noise (looped randomly selected CVCV-CVCV pseudo-words). The CVCV target words were played twice (e.g. /tigu tigu/) to make it easier for the listener. Consonants and vowels were /p, b, t, d, k, g, m, n, s, h, i, a, u/ and had been level normalised for equal intelligibility (Cameron et al., 2020). Participants heard a 200 ms 1 kHz warning tone followed by a 300 ms silent gap before the CVCV token. First the participants completed a phoneme familiarisation phase in quiet as outlined in Cameron et al. (2020)

After the familiarisation phase, separate practice and test phases were completed in two conditions. The first condition was the spatially-separated condition, where the target tokens were presented at 0° azimuth and the distractors were presented at +90° and at -90° azimuth. The second condition was the co-located condition, where the target tokens and distractors were all presented at 0° azimuth. The distracter track level was set at a constant level of 65 dB SPL. Target CVCV tokens were randomly presented at an initial SNR of +10 dB (75 dB SPL). In the practice phase, five CVCV trials was given prior to commencement of both the co-located and spatially-separated test conditions. In both the practice and test conditions, the target voice level was adjusted adaptively depending on the number of phonemes correctly perceived in each trial, as follows: zero correct: +3 dB; one correct: +2 dB; two correct: +1 dB; three correct: no change; four correct: -2 dB (or -4 dB *before* the first upward reversal in the spatially-separated condition). The speech reception threshold for each participant was calculated as the mean of the target levels after the first reversal (including the next target level that would have been presented after the last trial) minus the distractor level (i.e. 65 dB SPL). A maximum of 30 CVCV tokens were presented in the test phase. If the adjusted standard error (aSE; Cameron and Dillon, 2007b) of the mean was less than 1.0 dB and a minimum of 17 measurement trials (i.e. from trial four and after the first upward reversal) had been completed, the test stopped. Adults were retested on the LiSN-U four to six weeks after their initial test (mean 35 days). Children were tested four to eight weeks after their initial test (mean 39 days) with the longer timeframe being due to school holidays.

**Results**

Figure 1 shows the variation in performance at test and retest as a function of age. An analysis of variance (ANOVA) was conducted to assess test-retest improvement and the interaction with the age group for the spatially-separated, co-located, and spatial advantage measures in dB. Participants improved significantly on both the spatially-separated and co-located conditions, but not on the spatial advantage measure. The interaction between test-retest and age was not significant for the spatially-separated or spatial advantage measures, but was significant for the co-located condition. This difference is probably driven by larger than typical improvement for the 9-year-old group and smaller than typical improvement for the 5-year-old group. The ANOVA results are shown in Table 1.

[Insert Figure 1 here]

[Insert Table 1 here]

A correlation analysis was run to determine the relationship between test and retest SRTs for the children and adults combined. For the spatially-separated condition a strong positive correlation was found ($r = 0.63$, $p < 0.001$, 95% confidence interval 0.51 to 0.72). For the co-located condition, a moderate positive correlation was found ($r = 0.50$, $p < 0.001$, 95% confidence interval 0.36 to 0.62). For the spatial advantage measure a moderate positive correlation was found ($r = 0.37$, $p < 0.001$, 95% confidence interval 0.21 to 0.51) (see Figure 2).

[Insert Figure 2 here]

Tables 2 and 3 show the calculations of the one-sided critical differences for children and adults used to determine whether a listener diagnosed with SPD has improved on the LiSN-U following remediation. Improvement on the spatially-separated, co-located, and spatial advantage measures should be greater than the mean test-retest study difference plus 1.64 x SDs of test-retest study differences.

[Insert Table 2 here]

[Insert Table 3 here]

## Discussion

The aim of this study was to assess the test-retest reliability of the LiSN-U in a typically-developing population including calculation of critical difference scores. ANOVA results assessing test-retest improvement showed the group average score improved significantly on both the spatially-separated and co-located conditions, but not for the difference between these (i.e. the spatial advantage measure). This is the same as the results found for the LiSN-S where paired-sample t tests showed significant test-retest differences for all base conditions but not for spatial advantage (Cameron & Dillon, 2007b). The reduced effect of practice demonstrates another advantage of using the spatial advantage comparison measure along with the benefit of it minimizing the effect of individual difference in cognitive or phonological abilities. Although it is possible for children with deficits in spatial processing to improve their spatial processing with practice (Cameron et al., 2012; Graydon, Van Dun, Tomlin, Dowell, & Rance, 2018), such improvement is based on around 20 hours of intense training with feedback provided. Consequently, a lack of improvement as a result of performing a test that takes just 10 minutes, for children with normal ability to start with, is not surprising.

While it is possible that this reduced effect of practice is caused by the larger random error component that is inevitable when using difference scores, this does not seem to be the major reason in this instance. Averaged across age, the baseline scores improved by 1.3 dB for the spatially separated condition and 0.9 dB for the co-located condition, but only by 0.4 dB for the spatial advantage measure (i.e. the difference score). This small mean difference, combined with the relatively large standard deviation of test-retest differences (3.0 dB for the children; 3.3 dB for the adults), resulted in the small improvement in spatial advantage not being statistically significant ($p = 0.14$ on a t-test). These test-retest improvements in mean scores are similar to those reported in other studies, for example, 0.1-1.1 dB (Cameron & Dillon, 2007b), 1.29 dB (Bamford & Wilson, 1979), and 0.67 (Wagener & Brand, 2005). Hagerman and Kinnefors (1995) however found a smaller test-retest SRT improvement of 0.13 dB. Although there was a (just) significant interaction of test-retest improvement with age in the co-located condition, we regard this as a chance result because of the non-monotonicity of improvement with age.

Test-retest correlations of 0.37-0.63 were similar to those found for LiSN-S of 0.3-0.8 (Cameron & Dillon, 2007b). The correlation was lower for the spatial advantage measure than the spatially-separated and co-located measures which presumably reflects the higher random measurement error that is present in the spatial advantage being a difference measure. For all three measures, the *r* values are affected by the range of performance in the sample. As this sample comprises typically performing children, the range of performance is correspondingly restricted resulting in smaller *r* values than would occur if the sample included children with deficits, which is a mathematical inevitability.

Additionally, critical difference scores were calculated for children and adults. Critical differences make it possible to assess whether any change in score following remediation is greater than that which could be just the combined result of practice and random measurement error. The critical difference scores were marginally higher for children compared to adults across measures. The critical difference score for children on the spatial advantage measure was 5.5 dB. The adult's score was 5.4 dB. In comparison, the spatial advantage measure critical difference score calculated for adults and children combined on the LiSN-S was 3.9. This difference is predominantly due to the slightly greater test-retest variance in LiSN-U for children and adults (i.e. SD = 3.0 and 3.3 dB respectively compared with 2.54 for LiSN-S). The critical differences are also larger than those found in adults by Bentler (2000) of 2.4-2.6 on the SIN. We acknowledge that the critical differences calculated in the current paper are for typically developing children, but are intended to be applied to children with spatial processing deficits after remediation occurs. We are not aware of any reason why practice effects or reliability should be any better or worse in children with deficits, but we note that this is a limitation of the study.

The aim of the LiSN-U is to assess spatial processing in children with a normal audiogram but difficulties hearing speech in noise. This test could however also be used to assess spatial processing in children with hearing impairment to establish the effects of hearing aids in enhancing speech sound identification in spatialized noise. This would need an alternative set up using spatially-separated loudspeakers rather than headphones. Normative data and test-retest reliability would need to be separately established for such a sound-field implementation, where reverberation in the test room and potential movement of the person being tested could both influence the results.

## Conclusions

The results of this study show that the LiSN-U has mean test-retest difference and test-retest reliability comparable to other tests that have proven useful in clinical practice. The LiSN-U appears to be suitable as a research tool for measuring speech sound recognition in spatialized noise on the basis of spatial cues, potentially no matter what language the listener speaks. The impact of native languages other than English on test performance is, however, yet to be evaluated. The calculation of critical differences can be utilized to determine whether individuals have improved after completing auditory training by an amount that cannot reasonably be attributed to practice on the test and chance. Clinical data is needed to compare LiSN-S and LiSN-U results to fully determine the ability of the LiSN-U to detect SPD and assess the effects of remediating it.

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**Professional meeting details**

Cameron, S., Mealings, K., Chong-White, N., & Dillon, H. (2018, May). Development of the Listening in Spatialized Noise – Universal test (LiSN-U). A language-independent test for spatial processing disorder. *Paper presented at* the *Audiology Australia National Conference 2018, Sydney, Australia.*

**Disclosure statement.** The authors report no conflicts of interest.

## References

Bamford, J., & Wilson, I. (1979). Methodological considerations and practical aspects of the BKB sentence lists. In J. Bench & J. Bamford (Eds.), *Speech-hearing Tests and the Spoken Language of Hearingimpaired Children* (pp. 146–187). London: Academic Press.

Bentler, R. A. (2000). List equivalency and test-retest reliability of the speech in noise test. *American Journal of Audiology*, *9*(2), 84–100.

Cacace, A. T., & McFarland, D. J. (1998). Central Auditory Processing Disorder in School-Aged Children. *Journal of Speech Language and Hearing Research*, *41*(2), 355. doi:10.1044/jslhr.4102.355

Cameron, S., & Dillon, H. (2007a). Development of the Listening in Spatialized Noise-Sentences Test (LISN-S). *Ear and Hearing*, *28*(2), 196–211. doi:10.1097/AUD.0b013e318031267f

Cameron, S., & Dillon, H. (2007b). The listening in spatialized noise-sentences test (LISN-S): Test-retest reliability study. *International Journal of Audiology*, *46*, 145–153. doi:10.1080/14992020601164170

Cameron, S., & Dillon, H. (2008). The Listening in Spatialized Noise–Sentences Test (LISN-S): Comparison to the prototype LISN and results from children with either a suspected (central) auditory processing disorder or a confirmed language disorder. *Journal of the American Academy of Audiology*, *19*(5), 377–391.

Cameron, S., & Dillon, H. (2011). Development and evaluation of the LiSN & Learn Auditory Training Software for deficit-specific remediation of binaural processing deficits in children: Preliminary findings. *Journal of the American Academy of Audiology*, *22*(10), 678–696. doi:10.3766/jaaa.22.10.6

Cameron, S., Dillon, H., & Newall, P. (2005). Three case studies of children with suspected auditory processing disorder. *Australian and New Zealand Journal of Audiology*, *27*(2), 97–112.

Cameron, S., Dillon, H., & Newall, P. (2006). The Listening in Spatialized Noise test: An auditory processing disorder study. *Journal of the American Academy of Audiology*, *17*(5), 304–318.

Cameron, S., Glyde, H., & Dillon, H. (2012). Efficacy of the LiSN & Learn auditory training software: Randomized blinded controlled study. *Audiology Research*, *2*(e15), 86–93. doi:10.4081/audiores.2012.e15

Cameron, S., Mealings, K. T., Chong-White, N., Young, T., & Dillon, H. (2020). The development of the listening in spatialised noise–universal test (LiSN-U) and preliminary evaluation in English-speaking listeners. *International Journal of Audiology*, *59*(4), 263–271. doi:10.1080/14992027.2019.1689431

Glyde, H., Cameron, S., Dillon, H., Hickson, L., & Seeto, M. (2013). The effects of hearing impairment and ageing on spatial processing. *Ear and Hearing*, *34*(1), 15–28. doi:10.1097/AUD.0b013e3182617f94

Glyde, H., Hickson, L., Cameron, S., & Dillon, H. (2011). Problems hearing in noise in older adults. Spatial processing disorder? *Trends in Amplification*, *15*(3), 116–126.

Graydon, K., Van Dun, B., Tomlin, D., Dowell, R., & Rance, G. (2018). Remediation of spatial processing disorder (SPD). *International Journal of Audiology*, *57*(5), 376–384. doi:10.1080/14992027.2018.1431403

Hagerman, B., & Kinnefors, C. (1995). Efficient adaptive methods for measuring speech reception threshold in quiet and in noise. *Scandinavian Audiology*, *24*(1), 71–77. doi:10.3109/01050399509042213

Kilman, L., Zekveld, A., Hällgren, M., & Rönnberg, J. (2014). The influence of non-native language proficiency on speech perception performance. *Frontiers in Psychology*, *5*, 1–9. doi:10.3389/fpsyg.2014.00651

Krizman, J., Bradlow, A. R., Lam, S. S. Y., & Kraus, N. (2016). How bilinguals listen in noise: Linguistic and non-linguistic factors. *Bilingualism*, *20*(4), 834–843. doi:10.1017/S1366728916000444

Rogers, C. L., Lister, J. J., Febo, D. M., Besing, J. M., & Abrams, H. B. (2006). Effects of bilingualism, noise, and reverberation on speech perception by listeners with normal hearing. *Applied Psycholinguistics*, *27*(3), 465–485. doi:10.1017/s014271640606036x

Schafer, E. C., Aoyama, K., Ho, T., Castillo, P., Conlin, J., Jones, J., & Thompson, S. (2018). Speech recognition in noise in adults and children who speak English or Chinese as their first language. *Journal of the American Academy of Audiology*, *29*(10), 885–897. doi:10.3766/jaaa.17066

Tabri, D., Chacra, K. M. S. A., & Pring, T. (2011). Speech perception in noise by monolingual, bilingual and trilingual listeners. *International Journal of Language and Communication Disorders*, *46*(4), 411–422. doi:10.3109/13682822.2010.519372

Wagener, K. C., & Brand, T. (2005). Sentence intelligibility in noise for listeners with normal hearing and hearing impairment: Influence of measurement procedure and masking parameters. *International Journal of Audiology*, *44*(3), 144–156. doi:10.1080/14992020500057517

**Tables**

Table 1: Test-retest and age interaction ANOVA results for spatially-separated, co-located, and spatial advantage measures.

| | | *SS* | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|---|---|
| Spatially- | Retest | 123 | 1 | 123 | 33.47 | <0.001 |
| separated | Retest*Age | 21 | 7 | 3 | 0.82 | 0.576 |
| | Error | 456 | 124 | 3 | | |
| Co- | Retest | 48 | 1 | 48 | 46.65 | <0.001 |
| located | Retest*Age | 17 | 7 | 2 | 2.36 | 0.027 |
| | Error | 127 | 124 | 1 | | |
| Spatial | Retest | 17 | 1 | 17 | 3.64 | 0.059 |
| Advantage | Retest*Age | 21 | 7 | 3 | 0.63 | 0.726 |
| | Error | 591 | 124 | 5 | | |

Table 2: Calculation of the one-sided critical differences for children (n = 109) needed for improvement on retest that is unlikely to be due to practice effects and day-to-day fluctuations in performance.

| Condition | Correction Factor (Mean Retest-Test Difference) dB | SD of Mean Retest-Test Difference) dB | 1.64xSD dB | Critical Difference (Including Corrections) dB |
|---|---|---|---|---|
| Spatially-separated | -1.0 | 1.6 | 2.6 | -3.6 |
| Co-located | -1.5 | 2.6 | 4.3 | -5.8 |
| Spatial advantage | 0.6 | 3.0 | 4.9 | 5.5 |

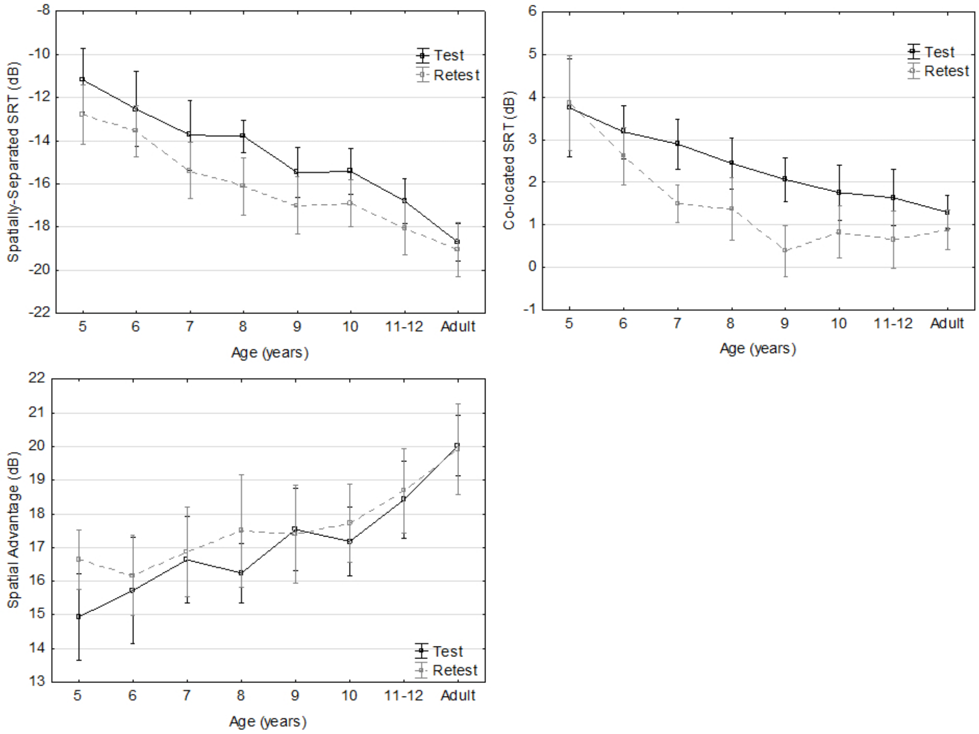
Table 3: Calculation of the one-sided critical differences needed for adults (n = 23) for improvement on retest that is unlikely to be due to practice effects and day-to-day fluctuations in performance.

| Condition | Correction Factor (Mean Retest-Test Difference) dB | SD of Mean Retest-Test Difference) dB | 1.64xSD dB | Critical Difference (Including Corrections) dB |
|---|---|---|---|---|
| Spatially-separated | -0.4 | 1.0 | 1.6 | -2.0 |
| Co-located | -0.3 | 2.8 | 4.6 | -4.9 |
| Spatial advantage | 0.1 | 3.3 | 5.3 | 5.4 |

**Figure Captions**

Figure 1: Test-retest comparisons of the spatially-separated, co-located, and spatial advantage scores in dB as a function of age. Bars represent 95% confidence intervals.

Figure 2: Scatterplots comparing test-retest correlations for the spatially-separated, co-located, and spatial advantage measures for the adults and children.

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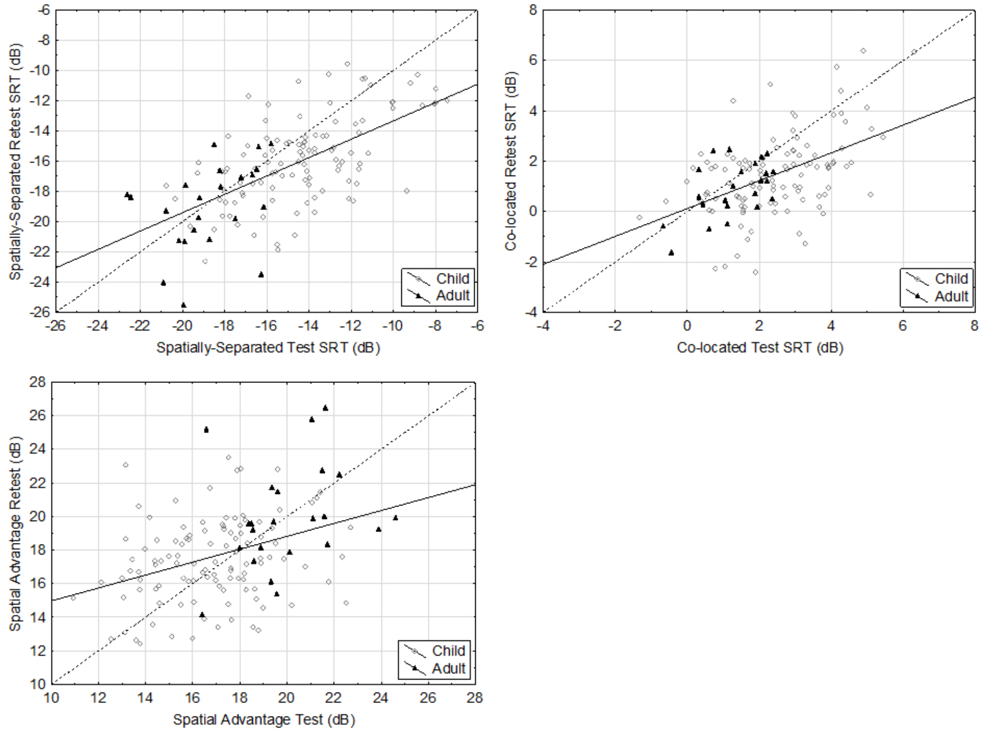


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