TECHNICAL REPORT

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Overview

SCAN—3 for Children: Tests for Auditory Processing Disorders (SCAN—3:C) is an individually administered battery of tests designed to identify auditory processing disorders in children ages 5 years through 12 years. *SCAN—3:C,* a revision of *SCAN—C, Test for Auditory Processing Disorders in Children – Revised,* consists of three screening tests, four diagnostic tests, and three supplementary tests. The screening tests can be used by audiologists, speech-language pathologists, and other professionals trained in standardized assessment to quickly determine if a child is at risk for an Auditory Processing Disorder (APD). The diagnostic tests can be administered to those who have been identified by the screening tests or by other means as being at risk for an APD, and/or to obtain diagnostic information that will, in combination with observations and other information, enable you to make diagnostic decisions about APD.

Revisions in the New Edition

SCAN—3:C was developed with the following goals:

- Include tests of temporal processing;
- Increase the difficulty of the Filtered Words test to increase the ceiling;
- Include additional tests of differing signal-to-noise ratios to enable the clinician to better understand the ratio at which the child performs well or poorly;
- Improve scoring of Competing Sentences so partially correct responses can be credited;
- Include a free recall response mode for Competing Words;
- Change the scoring of Competing Words so that only responses given in the directed order are credited as correct;
- Reconfigure SCAN—C as a battery of tests: screening tests with criterion-referenced scores, and diagnostic and supplementary tests with scaled scores; and
- Provide the prevalence of ear advantage for all tests.

SCAN—3:C Tests

The SCAN—3:C test battery includes eight tests that evaluate auditory processing abilities in the areas of temporal processing, listening in noise, dichotic listening, and listening to degraded speech:

Gap Detection is a screening test that measures the ability to detect brief silent gaps of variable durations (measured in milliseconds) between tone pairs. The child is asked to report whether one or two tones are heard. Failing this screening test indicates a need for further evaluation for a temporal processing disorder.

Auditory Figure Ground +8 dB which can be administered as a screening test or a diagnostic test, assesses the ability to process speech in the presence of background noise at a +8 dB signal-to-noise ratio (the stimulus words are 8 dB greater intensity than the multi-talker background noise). The child is instructed to "Say the word…" at the same time he or she hears the multi-talker speech in the background. Abnormal findings on tests of speech in noise can indicate an APD specific to listening in noise, as opposed to distractibility due to an attention deficit disorder.

Competing Words—Free Recall is used for screening and supplementary assessment. The test assesses the ability to process competing speech signals by presenting a different monosyllabic word to each ear simultaneously (a dichotic listening test). The child is instructed to repeat both words in any order. A score in the borderline or disordered range typically indicates an APD.

Filtered Words is a diagnostic test used to assess the ability to process distorted speech by presenting monosyllabic words low-pass filtered at 750 Hz. The child is instructed to "Say the word…" he or she hears. A child who obtains a low score on this test may have difficulty attending to and understanding speech in situations in which part of the acoustic signal is distorted or missing.

Competing Words—Directed Ear, a diagnostic dichotic listening test, differs from the free recall response mode by requiring the child to repeat both words in a directed order. Scoring of this test reflects the prescribed order. Results of dichotic testing provide information about the maturation of the neurological pathways of the central auditory nervous system and about hemispheric language dominance.

Competing Sentences provides diagnostic information about the child's ability to process competing speech signals. Pairs of unrelated sentences are presented to the right and left ears. The child is instructed to repeat the sentence heard in one ear. Poor overall performance on this test indicates the presence of an APD and is consistent with neurologically-based language and learning disabilities and provides additional information on the use of linguistic cues to interpret speech.

Auditory Figure-Ground +12 dB is a supplementary test used to assess the ability to process speech in the presence of background noise at a +12 dB signal-to-noise ratio. The child is instructed to "Say the word…" at the same time he or she hears the multi-talker speech in the background. This test can be administered to enable you to make appropriate recommendations for providing optimal listening conditions. A child who performs poorly on this test should be referred for further assessment of listening in noise.

Auditory Figure-Ground 0 dB is a supplementary test used to assess a child's ability to process speech that is presented at the same intensity (i.e., perceived as equally loud) as the background noise. The child is instructed to "Say the word…" at the same time he or she hears the multi-talker speech in the background. Administration of this test can provide information about how the child's auditory system functions when stressed by a more difficult signal-to-noise ratio.

Time Compressed Sentences is a supplementary test used to assess the ability to process degraded speech by presenting sentences that have been time compressed at 60%. The child is instructed to repeat the sentences he or she hears. A low standard score on this test indicates that the child has difficulty perceiving the rapidly changing acoustic features of speech.

Scores Reported

SCAN—3:C provides criterion-referenced scores and scaled scores for the screening tests, scaled scores for diagnostic and supplementary tests, and a composite standard score. Specific to the screening tests, Gap Detection has only a criterion referenced score, but Auditory Figure Ground +8 dB and Competing Words—Free Recall have scaled scores in addition to criterion-referenced scores. Percentile ranks and descriptive classifications are also provided for all the tests. Prevalence of ear advantages is provided for all tests except Gap Detection.

Ear advantage scores. The mathematical difference between the right ear and left ear raw scores is used to indicate ear advantage. A positive value indicates a right ear advantage and a negative value indicates a left ear advantage. Ear advantages are provided for all tests except the Gap Detection screening test. Ear advantage is a powerful indicator of possible hemispheric dominance for language and neurologically-based language/learning disorders. A child with a typically developing auditory nervous system will have similar right ear and left ear findings on all monaural tests of degraded speech (Auditory Figure-Ground, Filtered Words, and Time Compressed Sentences), and higher right ear scores than left ear scores on the dichotic listening tests: Competing Words—Directed Ear, Competing Words—Free Recall, and Competing Sentences.

SCAN—3:C Stimulus CD Technical Specifications

The auditory stimuli were recorded at the AUDiTEC studio in St. Louis, Missouri. Technical specifications were determined by the author. As the word and sentence stimuli were recorded, they were monitored to 0 with a VUE meter. Stimuli are presented at approximately 4-second intervals to allow for adequate response time. The CD has 51 tracks and contains the recorded test directions, practice items, and test items.

Testing Environment

SCAN—3:C is administered at a comfortable loudness level well above the audiometric threshold; therefore, administration in an audiometric sound-treated booth is not mandatory. You may administer the tests in a quiet room away from distractions and disruptions. If you use a two-room test booth, you will need a good quality talk-back system so you can clearly hear the child's responses. When an audiometer is used, the tests should be administered at 50 dB HL and kept at the same intensity for the duration of the tests. When an audiometer is not used, the tests should be administered at the child's most comfortable loudness level.

Standardization of SCAN—3:C

Standardization testing began in September of 2007 and ended in July of 2008. Data were collected from a sample of 525 children ages 5:0 through 12:11 by 105 speech-language pathologists and audiologists who were state-licensed and/or ASHA certified, and school psychologists in 32 states.

The SCAN—3:C normative sample is representative of the English speaking U.S. population of children ages 5:0-12:11 (U.S. Census, 2004). The sample was stratified for race/ethnicity, geographic region, and education level of the child's primary caregiver.

Tale 5.1 Normative Sample by Age

Age (years:months)	*n*	% of Sample
5.0–5.11	75	14.3
6.0–6.11	50	9.5
7.0–7.11	75	14.3
8.0–8.11	50	9.5
9.0–9.11	77	14.7
10.0–12.11	198	37.7
TOTAL	**525**	**100**

Note: This table is originally presented in the SCAN—3:C test manual, p.61.

Table 5.2 Normative Sample by Sex

Gender	*n*	% of Sample
Female	261	49.7.8
Male	264	50.3
TOTAL	**525**	**100.0**

Note: This table is originally presented in the SCAN—3:C test manual , p.61.

Table 5.3 Normative Sample by Race/Ethnicity

Race	*n*	% of Sample	% of U.S. Population
African American	80	15.3	14.5
Asian	17	3.2	4.0
Hispanic	72	13.7	17.4
White	337	64.2	60.9
Other	19	3.6	3.2
TOTAL	**525**	**100.0**	**100.0**

Note. U.S. Population data are from Current Population Survey, March, 2004: School Enrollment Supplemental File [CD-ROM] by U.S. Bureau of the Census, 2004, Washington DC: U.S. Bureau of the Census (Producer/Distributor).

Note: This table is originally presented in the SCAN—3:C test manual, p.61.

Table 5.5 Normative Sample by Primary Caregiver Education Level

Primary Caregiver Education Level	*n*	% of Sample	% of U.S. Population
11 years of school or less	40	7.6	11.1
12 years of school or GED	136	25.9.5	24.8
13–15 years of school	184	35.1	33.5
16 years of school or more	165	31.4	30.6

Note. U.S. Population data are from Current Population Survey, March, 2004: School Enrollment Supplemental File [CD-ROM] by U.S. Bureau of the Census, 2004, Washington DC: U.S. Bureau of the Census (Producer/Distributor).

Note: This table is originally presented in the SCAN—3:C test manual, p.62.

Table 5.4 Normative Sample by Geographic Region

Region	*n*	% of Sample	% of U.S. Population
Midwest	109	20.8	22.5
Northeast	93	17.7	17.8
South	185	35.2	35.7
West	138	26.3	24.0
TOTAL	**525**	**100.0**	**100.0**

Note. U.S. Population data are from Current Population Survey, March, 2004: School Enrollment Supplemental File [CD-ROM] by U.S. Bureau of the Census, 2004, Washington DC: U.S. Bureau of the Census (Producer/Distributor).

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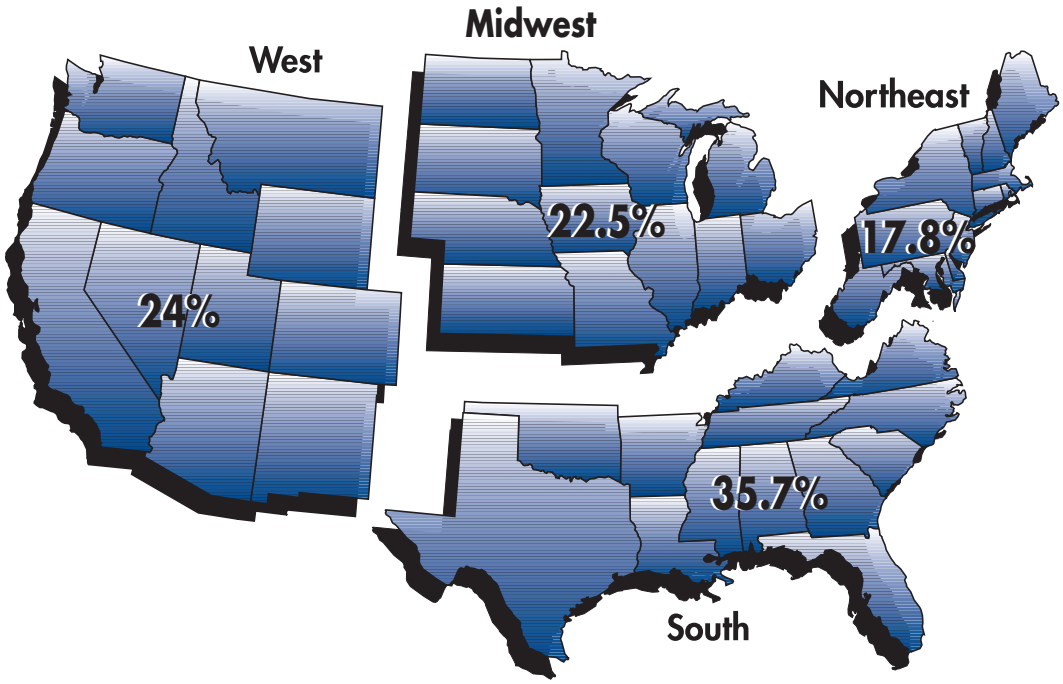

Evidence Based on Reliability

The reliability of a test rests on the accuracy, consistency, and stability of test scores across situations (Anastasi & Urbina, 1997). The reliability of SCAN—3:C was estimated using test-retest stability (data that show scores are stable across repeated administrations), internal consistency (data that show test items within a test or group of tests are homogenous and yield consistent estimates of ability), and interscorer reliability (data that show scoring is objective and consistent across examiners).

The test-retest stability coefficients ranged between .54 and .73 for the test scores and was .77 for the Auditory Processing Composite (APC). The average reliability coefficients of the tests that compose the APC range from .72 to .91. The average reliability coefficient is excellent for the APC score, .91. All SCAN—3:C standardization tests were scored by two independent scorers, and evidence of interscorer agreement was obtained using the standardization sample. Interscorer agreement is very high, ranging from .98 to .99, suggesting that the tests in the SCAN—3:C battery of tests have objective, clearly to understand scoring directions.

Standard Error of Measurement

The standard error of measurement (SEM) is a statistic that estimates the amount of error present in an assessment and the SEM is directly related to the test's reliability coefficients and the variability (standard deviation) of the test scores. The smaller the SEM, the more confident you can be in the precision of the test results. The SEMs for SCAN—3:C test and composite score are reported in terms of standard score units in Table 5.10. Note that the relatively larger composite score SEMs in the table do not indicate a higher level of error in this score than in the test scores, but rather the greater variability of the composite score and the different score metric employed with the composite score versus test scores; test scaled scores range from 1 to 19, the composite standard score ranges from 40 to 160.

Evidence Based on Validity

Evidence of test validity refers to the degree to which specific data, research, or theory support that a test measures the construct or content it purports to measure and is applicable to the intended population (AERA et al., 1999). Different sources of evidence represent different aspects of validity; however, these sources do not represent distinct types of validity. The SCAN—3:C addresses evidence based on test content, response processes, internal structure, and special group studies.

Test Content. The SCAN—3:C content and test construction was designed to reflect auditory processing abilities in children ages 5:0-12:11. The auditory processing abilities sampled using SCAN—3:C (e.g., auditory performance in competing acoustic signals, auditory performance with degraded acoustic signals, and temporal discrimination) are documented in the ASHA 2005 Technical Report on (Central) Auditory Processing Disorders (ASHA, 2005).

Response Processes. Throughout the test's development evidence of validity was accumulated through empirical and qualitative examination of response processes. For example, on the Competing Word – Directed Ear test, children were asked why they responded with the word that was presented to one ear rather than the word that was presented to the other ear. Examiners reported observations about the test-taking behavior of children which indicated that the children were listening to the auditory stimuli and indeed attempted to repeat what they heard. An analysis of a type of response identified as a "blend" was conducted to see if the frequency of occurrence of blends was significant enough to include in the scoring system.

Internal Structure. SCAN—3:C is a battery of tests for APD, many of which assess different areas of auditory processing (e.g., listening in noise, listening to a low-pass filtered signal, dichotic listening) so it was not expected that all the tests within SCAN—3:C would correlate highly with each other. The highest correlation between tests is a moderate correlation between Competing Words – Free Recall and Competing Words – Directed Ear (.71). Both are single-word dichotic listening tests, but differ in instructions to the child. Competing Words – Directed Ear has the highest correlation with the APC (.76); the other three tests that contribute to the APC have correlations in the .60s.

Special Group Studies. A study of 40 children, ages 5:0-12:11 diagnosed with APD was completed as part of the validation of SCAN—3:C. All children had a diagnosis of APD from a certified or licensed audiologist, or a composite score on a test of auditory processing at one or more standard deviations below the mean. Each child in the APD group was matched to a control subject from the standardization sample based on age, primary caregiver education level, and race/ethnicity. Descriptive group comparison statistics indicate that test and composite scores effect sizes are moderate to large, highlighting the ability of SCAN—3:C to discriminate between children with normal auditory processing abilities and those with APD.

Table 5.10 Standard Errors of Measurement Based on Internal Reliability Coefficients for Test and Composite Scores by Age and Across All Ages

Age	5:0–5:11	6:0–6:11	7:0–7:11	8:0–8:11	9:0–9:11	10:0–12:11	Average *SEM*
n	***75***	***50***	**75**	**50**	**77**	**198**	**525**
Test Composite							
Competing Words–Free Recall	1.50	1.37	1.12	1.31	1.47	1.20	1.34
Time Compressed Sentences	1.24	1.37	2.01	1.41	1.92	1.62	1.62
Auditory Figure-Ground +12 dB	1.64	2.01	1.80	2.08	1.92	2.12	1.94
Auditory Figure-Ground 0 dB	1.59	1.80	1.62	1.82	1.80	1.72	1.73
Auditory Figure-Ground +8 dB	1.31	1.56	1.27	1.97	1.41	2.08	1.63
Filtered Words	0.95	1.08	0.99	0.99	0.90	1.12	1.01
Competing Words–Directed Ear	1.34	1.37	1.16	1.08	1.20	0.99	1.20

Note. The average SEMs were calculated by averaging the sum of the squared SEMs for each age group and obtaining the square root of the result.

This table is originally presented in the SCAN-3:C test manual.

Diagnostic Accuracy and Clinical Utility

The diagnostic accuracy of SCAN—3:C was evaluated using two diagnostic validity statistics that describe how a test performs: sensitivity and specificity. Sensitivity reports the probability that someone who has APD will test positive for it. Specificity reports the probability that someone who does not have the condition will test negative. Because a child can have difficulty with one or more areas of auditory processing (e.g., temporal processing, dichotic listening) but not in another (e.g., listening in noise), using one screening test as a predictor for classifying APD in any or all areas has limitations.

Sensitivity and specificity for the screening tests range from .25 to .88 depending on the cut score chosen. The results indicate good sensitivity (.78) if the cut score is <8, and excellent specificity at a cut score of <3. Sensitivity and specificity for the screening and diagnostic tests range from .20 to .90 depending on the cut score chosen. If the cut score is <8, 90% of those children previously diagnosed with APD were correctly identified as such by the SCAN—3:C screening and diagnostic tests and 20% of those without APD were correctly classified as not having APD by the six SCAN—3:C tests.

Summary

SCAN—3 for Children: Tests for Auditory Processing Disorders (SCAN—3:C) is an individually administered battery of tests designed to identify auditory processing disorders in children ages 5 years through 12 years. Studies conducted during standardization provide evidence of the reliability and validity of SCAN—3:C scores and the accuracy of the scores in making decision about children's auditory processing abilities. The screening tests can be used to quickly determine if a child is at risk for an APD. The diagnostic tests can provide information that will, in combination with observations and other information, enable you to make diagnostic decisions about whether a child has APD.