

Department of Veterans Affairs Compact Disc Recording for Auditory Perceptual Assessment: Background and Introduction

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Abstract

Materials for use in auditory perceptual assessment of central auditory problems are widely divergent in quality, usefulness, and complexity. These circumstances make interpreting results a highly provincial affair. Comparison of results between different clinics and laboratories is often difficult or impossible. Norms by which to judge an individual's performance are often applicable for only one version of a given test and may not be appropriate for another version of the "same" test. The pressing need for standardization of a battery of central auditory tasks that is useful in clinical endeavors and in laboratory experiments is obvious. If that battery could encompass a wide range of complexity, and if the items in it were produced with very high quality, then its value would increase. The materials previewed in this introductory article and in seven other articles in this journal edition were developed to address some of these issues. Monotic, diotic, and dichotic materials using speech and tone stimuli were created. They were produced on compact disc under the sponsorship of the Department of Veterans Affairs and with the assistance of many institutions and individuals in the United States. In the articles that follow this one, data generated from their use with young, normal listeners are presented.

Key Words: Central auditory nervous system (CANS), central auditory test materials, central auditory tests, compact disc

The Department of Veterans Affairs compact disc (VA-CD) recording formally known as *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* provides a collection of high-quality materials for use in evaluating what is commonly called central auditory function. Its development and test were directed by one of the authors (RHW). The need for standardization of a central battery of auditory tasks that would be clinically and experimentally useful and that would encompass a wide range of complexity produced the

procedures and normative data reported in this series of articles. The materials are in convenient format and are of exceptional quality for clinical materials. Field tests were done at many institutions across the United States. The tonal and speech materials contained on the disc were selected from materials in the public domain or through the generosity of individuals responsible for them. The roles of these institutions and individuals, and of agencies within the Department of Veterans Affairs, are acknowledged later.

The VA-CD for perceptual assessment was produced for several reasons, many of which were inherent in the quality and permanence afforded by compact disc technology. Inadequate control of stimulus parameters, differences in mechanical reproduction devices, wear and tear of magnetic tape, vulnerable signal/noise ratios, and marked differences in the actual composition of test materials all called the same thing (e.g., "filtered speech" tests) all

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contributed to variability, uncertainty, and inability to generalize results and led to the decision to make the disc. It was obvious that inadequate control of such factors often made comparison of results between clinics or even between different sessions in one clinic tenuous, that this has been a particular problem in the area of central auditory tests, and that many of these problems could be eliminated by care in choosing and producing materials with compact disc technology.

A further source of confusion has been the substantial, but somewhat unfocused, accumulation of research over the years about a myriad number of tests available to evaluate central auditory nervous system (CANS) function. To our knowledge, this is a rare attempt to create a clinical tool that: (a) includes a wide array of CANS tests; (b) allows easy access to any one procedure or group of procedures; (c) features high-quality production and resistance to erosion from use; and (d) is supported by extensive normative testing and psychometric evaluation.

The materials on the compact disc include: 1000-Hz calibration tones; spondaic words in noise for measuring a speech masking-level difference; dichotic musical chords (simultaneous and with 90-msec onset time staggers); dichotic nonsense syllables (simultaneous and with 90-msec onset time staggers); dichotic digits (single-digit pairs); dichotic sentences; segmented, alternated consonant-nucleus-consonant (CNC) syllables (vowels in one ear, consonants in the other [VIOECITO]); high- and low-pass filtered word lists; frequency-variable tone patterns; duration-variable tone patterns; 45 percent and 65 percent time-compressed speech materials, half of which are additionally compromised by 0.3-sec reverberation time; and 100-Hz pulsed tones for phase calibration. See Table 1 for a summary of disc contents.

The tests on this disc assess various aspects of auditory processing and various CANS/perceptual processes. As is evident from the list of procedures, materials on the disc permit definition of monotic, diotic, and dichotic abilities of a listener. Although such definition is accomplished primarily with speech materials, some attention is paid to materials that use tone patterns involving frequency and duration. Some tests are well known (e.g., filtered speech materials), and some, like the tone tests and the speech tests combining time compression and reverberation, are fairly new. Several of the tasks are thought to require an ability that is dependent upon adequate auditory

brainstem or brain function. Integration of information from each ear, as in the VIOECITO procedure, is an important binaural phenomenon. Masking-level differences also appear to be dependent upon low brainstem integrity. Frequency and duration patterns evidently involve processing by both brain hemispheres, as well as interhemispheric interactions. Dichotic speech tasks — such as dichotic sentence identification, dichotic digits, and dichotic syllable recognition — have all been shown to be sensitive to lesions primarily of auditory areas of the brain. Dichotic chords may serve a similar purpose. Time-altered speech at higher compression ratios can be used in detecting cortical dysfunction. And some of the procedures on the compact disc have been chosen not only because of lesion-effect data, but also because of their known or potential applicability in the study of people with presumed central auditory processing difficulties. (References relevant to the relationships between disorders and test results are given at appropriate spots in the article covering each test.)

SUBJECTS

Each of the subsequent articles in this series reports data from what are called "compact disc trials" that involved 120 young adults with self-described normal hearing. With few exceptions, they were naive listeners (not audiology students). Their ages ranged from 17–32 years, with a mean age of 23 years ($SD = 3.1$ yrs). They were selected by participating investigators at nine major universities and/or medical centers throughout the United States (see Acknowledgment). Twenty-one males and 99 females participated, 107 of them self-identified right-handers. Details of their hearing sensitivity for tones are given in Table 2.

METHOD

Materials

The speech materials contained on the compact disc were digitized from analog master tapes using an analog-to-digital converter (Antex, Model SX10) with the following characteristics: 16-bit resolution, 20,000 samples/sec, and 8800-Hz filter cut-off with 96 dB/octave rejection. The tonal materials were generated digitally using in-house routines in use at the authors' laboratories. All materials were compiled on digital audio tape (Sony, Model PCM-

Table 1 Contents of the VA-CD Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0

<i>Track/Time</i> (Min/Sec)	<i>Channel*</i>	<i>Content</i>
01/ (0:32)	L	1000-Hz calibration tone
	R	1000-Hz calibration tone
02/ (5:18)	L	Spondees, S _p N ₀ masking-level difference (MLD)
	R	Spondees, S _p N ₀ masking-level difference (MLD)
03/ (4:56)	L	Dichotic synthetic musical chords
	R	Dichotic synthetic musical chords
04/ (4:57)	L	Dichotic chords with 90-msec onset lag
	R	Dichotic synthetic musical chords
05/ (3:02)	L	Dichotic nonsense syllables (CVs)
	R	Dichotic nonsense syllables (CVs)
06/ (3:04)	L	Dichotic syllables with 90-msec onset lag
	R	Dichotic nonsense syllables (CVs)
07/ (3:39)	L	Dichotic monosyllabic digits
	R	Dichotic monosyllabic digits
08/ (4:59)	L	Dichotic synthetic sentences
	R	Dichotic synthetic sentences
09/ (3:54)	L	VIOECITO-consonant segments (CNCs), list 5A
	R	VIOECITO-vowel segments (CNCs), list 5A
10/ (3:55)	L	VIOECITO-consonant segments (CNCs), list 5B
	R	VIOECITO-vowel segments (CNCs), list 5B
11/ (4:00)	L	NU #6, high-pass filtered, list 3C
	R	NU #6, low-pass filtered, list 3C
12/ (4:04)	L	NU #6, high-pass filtered, list 4C
	R	NU #6, low-pass filtered, list 4C
13/ (7:03)	L	Frequency tonal patterns
	R	Duration tonal patterns
14/ (3:59)	L	NU #6, 45% compressed, 0.3-sec reverb, list 5
	R	NU #6, 45% time-compressed, list 5
15/ (4:01)	L	NU #6, 45% compressed, 0.3-sec reverb, list 6
	R	NU #6, 45% time-compressed, list 6
16/ (4:02)	L	NU #6, 65% compressed, 0.3-sec reverb, list 7
	R	NU #6, 65% time-compressed, list 7
17/ (4:02)	L	NU #6, 65% compressed, 0.3-sec reverb, list 8
	R	NU #6, 65% time-compressed, list 8
18/ (0:18)	L	100-Hz, pulsed phase calibration tone
	R	100-Hz, pulsed phase calibration tone

*L = left, R = right. Note that "Left Channel" and "Channel 1" are used interchangeably in the text and in instructions accompanying the VA-CD.

2500A) from which the master tape was made on Sony 1630 format. Details of test item construction for some of the experiments and for the compact disc trials are given, as necessary, in descriptions of each test. Detailed information on the VA-CD including the exact contents of each track on the disc and references to other work employing similar tests accompanies the disc.

Calibration

On track 1 of the VA-CD, both channels contain a 300-msec, 1000-Hz tone burst, followed by a 1-sec silent interval and then a 30-sec, 1000-Hz calibration tone that reflects the peaks of the speech materials as monitored on a calibrated VU meter (Green et al, 1959; Lilly,

1967). The tone burst can be used to check the ballistic characteristics of a VU meter. The needle indicator on a calibrated VU meter will swing from -20 VU to 0 VU with minimal overshoot when a 300-msec tone burst (0 VU amplitude) is placed across the meter. It must be noted that many meters used on audiometers are not "true" VU meters and/or are not properly calibrated (ANSI, 1954). The 1000-Hz calibration tone, therefore, may not accurately reflect the peaks of the speech materials on non-VU meters and on noncalibrated VU meters. For a variety of reasons, the materials on several tracks do not peak at 0 VU. These exceptions are noted in the instruction booklet that comes with the disc.

On track 18 of the VA-CD, an 18-sec stereo track contains 100-Hz tone bursts that are 50

Table 2 Pure-Tone Thresholds of Subjects used in VA-CD Normative Trials

Ear	Frequency (Hz)					
	250	500	1000	2000	4000	8000
Right						
Mean	5.3	4.2	3.6	2.8	4.0	6.1
SD	4.6	3.9	4.0	4.3	5.1	6.4
Range	-5/15	-5/15	-5/15	-5/25	-5/30	0/35
Left						
Mean	5.2	3.4	3.0	3.5	5.0	6.8
SD	4.9	4.1	3.7	4.6	5.2	5.9
Range	0/20	-5/15	0/15	-5/20	-5/20	0/25

dB HL (ANSI, 1989).

msec on and 50 msec off, recorded 180 degrees out of phase on the two channels. These tone bursts are for the relative phase calibration of the two channels of audiometers. The procedure for phase calibration requires an NBS-9A, 6-cm³ coupler, a microphone, a microphone amplifier or sound-level meter, and an oscilloscope. The output of the amplifier or meter is fed to the oscilloscope. If the earphones are in phase with each other, then a sequential measurement of the output of each earphone will reveal tone bursts that are out of phase at the oscilloscope (i.e., the onset of the waveform through one earphone will be positive, whereas the onset of the waveform through the other earphone will be negative). If these results are not obtained, then reversing the leads to one earphone should produce the correct phase relation.

Experimental Trials

The size of the subject population used in trials for each of the tests on the compact disc (VA-CD) was determined by a number of factors, most important of which was the detail in which it was desirable to define a psychometric function of performance. For some of the procedures, adjunct data collection was done and is reported when relevant. When true, these data are reported as "experiments," in contrast to the "compact disc trials." Instructions to the investigators included a requirement that practice trials be conducted prior to data collection. Instructions to the subjects (i.e., the subjects' tasks) are included in each report.

SUMMARY

The need for standardized materials with which to investigate the capabilities of the

CANS is longstanding. The related need for such materials to be carefully produced, evaluated, and described and for the delivery medium through which they are presented to be relatively stable over time is also known. The VA-CD recording *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* is an attempt to address these needs.

The VA-CD is the culmination of work and contributions by many clinicians and investigators across the United States. It contains a variety of materials that are known to allow better understanding of the monotic, diotic, and dichotic listening skills of people with normal and disabled central auditory systems. It provides materials that should engender confidence in clinicians and researchers who desire to compare results of their investigations.

The performance of groups of young listeners with no hearing complaints who responded to the tasks recorded on the VA-CD is presented in the series of articles that follow this one. These studies provide baseline information on average performance by young listeners with good hearing and illustrations of the degree of confidence one can choose in differentiating normal listeners from abnormal listeners.

However, we emphasize that the data, error statistics, and confidence ranges given hereafter in succeeding articles are not intended for use as absolute standards. Our intent was to create a set of good materials that would last and to provide a framework in which the hard work of defining what is and is not normal behavior could be done. Part of the framework from the studies reported henceforth includes information that separates young listeners with good hearing into groups that allow one to build arbitrary false positive/false negative fences. Many people will use the materials on the VA-CD to test their own normal and abnormal populations and to construct their own dividing lines, which was the authors' intent. It was also our intent that the materials should be sufficiently well chosen, constructed, defined, and resistant to abuse so that clinics and/or laboratories could exchange and compare findings with confidence.

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