

Frequency (Pitch) and Duration Pattern Tests

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Abstract

Compact disc versions of the frequency (pitch) and duration pattern tests are reported. Results are similar to previous reports on these tests using taped materials. Mean performance of normal-hearing young adults for both pattern perception tests was approximately 90 percent. There was no effect of the two presentation levels used in this study. The compact disc version of these tests provides a high-fidelity measure of auditory pattern identification that can be administered easily.

Key Words: Central auditory function, duration patterns, frequency patterns

Two auditory pattern perception tests have been used in the clinical assessment of central auditory disorders. These tests are the frequency, or pitch, pattern test and the duration pattern test, and they are now available on compact disc (CD). The original taped versions of these tests were a direct outgrowth of well-grounded animal research.

Reports have shown that when the primary auditory cortex of an animal was ablated bilaterally, the ability to respond appropriately to patterns of tonal stimuli was compromised (Neff, 1961). Additionally, ablation of the insular region in cats resulted in the loss of temporal pattern discrimination (Colavita, 1974). This animal research, along with other reports suggesting that temporal processing was critical to the understanding of speech (Hirsh, 1967), motivated Pinheiro and Ptacek (1971) to develop pattern perception tests to be used with the neurologically compromised patient.

Some initial investigations using the frequency (pitch) pattern test indicated that it was sensitive to hemispheric lesions (Pinheiro, 1976) and to auditory processing dysfunction related to dyslexia (Pinheiro, 1977). This monaurally presented test often showed binaural deficits in people with brain lesions. A better understand-

ing of this "bilateral phenomena" was achieved with the report on auditory pattern perception in split brain patients (Musiek et al, 1980). This study supported the theory that both hemispheres were needed to decode the pattern and report it verbally. The left hemisphere is dominant for speech, language, and temporal ordering, whereas the right hemisphere recognizes acoustic contours and patterns (Kimura, 1964; Blumstein and Cooper, 1974). If the two hemispheres exchange information, then the corpus callosum must be involved. Therefore, the findings of bilateral deficits on patterns with split brain subjects made sense. Interestingly, the split brain patients could hum the patterns correctly, indicating that the right hemisphere was appropriately processing the signal; however, verbal report was not possible without transferring to the left hemisphere for linguistic labelling. At about the same time that the original theories of bihemispheric interactions were formed, some interesting observations on pattern reversals were made.

As reported originally by Pinheiro and Ptacek (1971), normal-hearing subjects have a small percentage of reversals; based on this, reversals were not counted as incorrect. However, cases of patients with brain abnormalities demonstrating a large number of reversals changed the way the frequency pattern test was scored. Currently, reversals on the frequency or duration pattern test are considered incorrect.

Reports in 1980 and 1982 showed that the frequency pattern test is valuable for detecting central auditory processing deficits in children

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with learning disabilities (Musiek and Geurkink, 1980; Musiek et al, 1982). In 1987, an extensive study on patients with cochlear, brainstem, or cerebral lesions showed that the frequency pattern test was highly sensitive for cerebral involvement and was relatively resistant to mild/moderate cochlear hearing loss (Musiek and Pinheiro, 1987). For brainstem lesions, this pattern perception test was only moderately sensitive.

The auditory duration pattern test (Musiek et al, 1990) is similar to the frequency pattern test and demonstrates good sensitivity and specificity. The duration pattern test can also detect certain cerebral lesions that the frequency pattern test cannot, but the opposite is also true. Hence, the processes underlying duration pattern perception appear to be different than those of frequency pattern perception.

Both the frequency and duration pattern perception tests appear to have a high test efficiency; however, they do not provide laterality information. As mentioned earlier, lesions in either hemisphere or the corpus callosum often result in bilateral ear deficits; therefore, no laterality information is available from the test results. Early studies indicated that musicians perform better than nonmusicians on frequency and duration pattern tasks (DeFosse and Pinheiro, 1978). Therefore, when testing musicians, clinicians should expect higher scores using pattern perception tests.

Because of the inherent changes in the acoustics of the recording, adapting the frequency and duration patterns onto a CD required the collection of new norms. The following is information about both pattern tests on the CD.

METHOD

Subjects

Please refer to the introductory article in this series by Noffsinger et al (1994), which defines the subjects in this research. A description of the compact disc is also included in this introductory article.

Frequency Patterns

The prototypic frequency pattern (Fig. 1) is composed of three 150-msec tones (10-msec rise-fall times) and two 200-msec intertone intervals. The tones in each frequency pattern are combinations of two sinusoids, 880 Hz and 1122

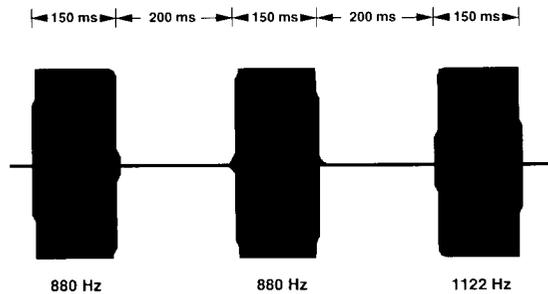


Figure 1 Digitized waveforms of the frequency pattern L-L-H with amplitude (Y axis) and time (X axis) as the coordinates.

Hz, which are designated a low frequency (L) and a high frequency (H), respectively. Thus, there are six possible combinations of the three-tone sequence (LLH, LHL, LHH, HLH, HLL, and HHL). Figure 1 depicts two 880-Hz tones followed by one 1122-Hz tone, which is the LLH sequence. The tones were generated digitally and shaped with a cosine-squared function. The CD contains 60 frequency patterns (six patterns by 10 randomizations) that have approximately 6-sec interpattern intervals.

Duration Patterns

The duration patterns (Fig. 2) are composed of three 1000-Hz tones and two 300-msec intertone intervals. The tones in each duration pattern are either 250 msec or 500 msec in

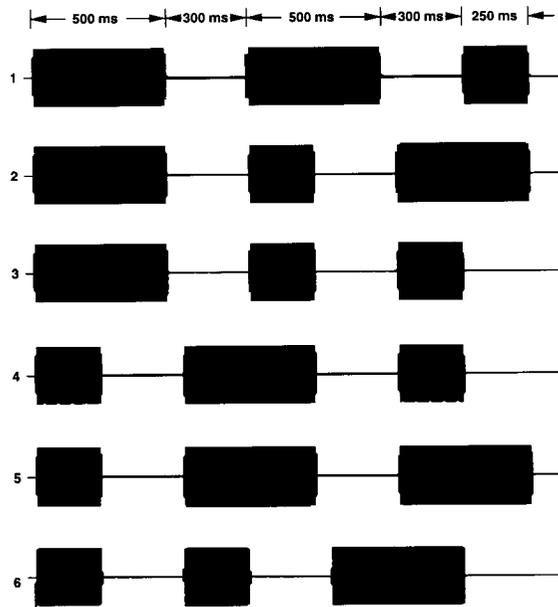


Figure 2 Digitized waveform of the six duration patterns with amplitude (Y axis) and time (X axis) as the coordinates.

duration and are designated as short duration (S) and as long duration (L), respectively. Each tone was generated digitally and has 10-msec rise-fall times shaped with a cosine-squared function. There are six possible combinations of the three-tone sequence (LLS, LSL, LSS, SLS, SLL, and SSL). The CD contains 60 duration patterns (six patterns by 10 randomizations) that have approximately 6-sec interpattern intervals.

PROCEDURES

For the CD trials, both the frequency and duration patterns were presented at either 20 dB HL (ANSI, 1989) or 50 dB HL. Because the materials were presented through the speech channel of an audiometer, these hearing levels corresponded to approximately 40 dB SPL and 70 dB SPL, respectively. Sixty of the subjects received the frequency patterns at the lower level and the duration patterns at the higher level. The remaining 60 subjects received the frequency patterns at the higher level and the duration patterns at the lower level. All 60 patterns were presented to one ear.

The subjects were instructed that they would hear sets of three consecutive tones that varied in either pitch or duration. The task of the subject was to repeat by verbalizing the tonal pattern with the frequency patterns (e.g., high-low-high, low-low-high) and with the duration patterns (e.g., long-short-long, short-short-long). The subjects were encouraged to guess if they were unsure of the pattern. The subjects received face-to-face practice where visual cues were provided while the examiner hummed pattern examples. A random starting point on the track was accessed and six patterns were presented for practice. Following the practice items, the index was reset to the start of the track, and the 60 test patterns were presented.

RESULTS AND DISCUSSION

There was no effect of presentation on level or performance, as mean scores were essentially the same at both levels used for both types of patterns (Fig. 3). The mean scores for both tests were approximately 90 percent correct, with less variability at the lower presentation levels. Because of the skewed distributions (Fig. 3), the 90th percentile cut-off points were determined. For both levels of the frequency patterns, 90 percent of the scores were 78 per-

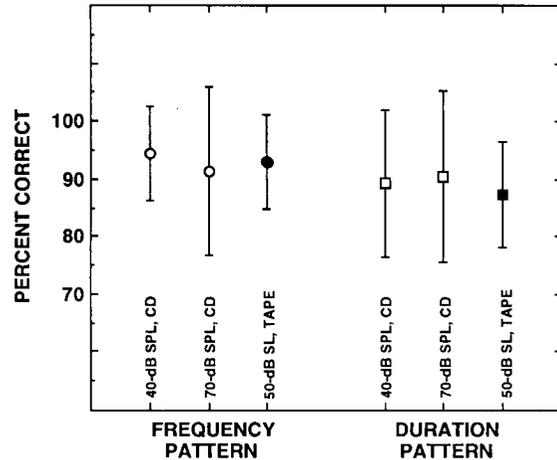


Figure 3 Mean percent correct and one standard deviation for frequency and duration patterns using the CD version at two intensities compared to previous findings using taped stimuli (Musiek and Pinheiro, 1987; Musiek et al, 1990).

cent correct or better. For both levels of the duration patterns, 90 percent of the scores were 73 percent correct or better. These values should be used to define normal performance for a young adult population.

With the CD trials, all 60 of the frequency patterns and all 60 of the duration patterns were presented to one ear. Clinically, however, usually only 30 patterns are presented to each ear. It was interesting, therefore, to evaluate performance on the CD trials in terms of the first and second parts of the 60-item test. With the frequency patterns, 90 percent of the subjects obtained performances on the respective halves (30 items each) that were within ± 3 items correct ($\pm 10\%$ correct) of one another. With the duration patterns, 85 percent of the subjects obtained performances on the respective halves that were within ± 3 items correct ($\pm 10\%$ correct) of one another. For the frequency patterns test, when the first and second 30-item parts were compared, the means were approximately 3 percent higher for the second part. For the duration patterns test, when the first and second 30-item parts were compared, the means were essentially the same.

Frequency and duration pattern results from the CD subject pool are similar to previously reported results for these two tests (Musiek and Geurkink, 1982; Musiek et al, 1990). The frequency and duration pattern results indicated nearly identical scores at two different presentation levels. This is similar to a recent study that reported no significant in-

tensity effects for as low as 10 dB SL (Pengilly, 1992).

The present experimental design did not seek to determine ear differences, since it has been well documented that neither frequency nor duration patterns demonstrate significant ear effects (Pinheiro and Godbey, 1973; Pinheiro, 1976; Musiek and Geurkink, 1982; Musiek et al, 1990; Pengilly, 1992). It should be stressed that practice is an important feature of helping the subject understand this test. Practice items can be accessed from the CD by randomly selecting items from the 60 test items before starting the test.

There are some considerations for administering a 30-item test. If a clinical decision is difficult because scores are near the cut-off criteria, the test should be repeated on the ear(s) close to the pass-fail score.

The CD version of the frequency and duration pattern tests provides a measure of central auditory function that is sensitive to cerebral lesions involving auditory areas. These tests have exceptional acoustic fidelity, and they can be administered easily.

REFERENCES

- American National Standards Institute. (1989). *Specifications for Audiometers*. (ANSI S3.6-1989). New York: ANSI.
- Blumstein S, Cooper W. (1974). Hemispheric processing of intonation contours. *Cortex* 10:146-158.
- Colavita F. (1974). Insular-temporal lesions and vibrotactile temporal pattern discrimination in cats. *Psychol Behav* 12:215-218.
- DeFosse C, Pinheiro M. (1978). *Perception of Dichotic Pitch Patterns by Musicians and Non-Musicians*. Presented at the annual meeting of the American Speech and Hearing Association, San Francisco, CA, November, 1992.
- Hirsh I. (1967). Information processing in input channels for speech and language: the significance of serial order on stimuli. In: Millikan C, Darley F, eds. *Brain Mechanisms Underlying Speech and Language*. New York: Grune and Stratton, 22-38.
- Kimura D. (1964). Left-right differences in the perception of melodies. *Q J Exp Psychol* 16:355-358.
- Musiek F, Baran J, Pinheiro M. (1990). Duration pattern recognition in normal subjects and in patients with cerebral and cochlear lesions. *Audiology* 29:304-313.
- Musiek F, Geurkink N. (1980). Auditory perceptual problems in children: considerations for the otolaryngologist and audiologist. *Laryngoscope* 90:962-971.
- Musiek F, Geurkink N. (1982). Auditory brainstem response and central auditory test findings for patients with brainstem lesions: a preliminary report. *Laryngoscope* 92:891-900.
- Musiek F, Geurkink N, Keitel S. (1982). Test battery assessment of auditory perceptual dysfunction in children. *Laryngoscope* 92:251-257.
- Musiek F, Pinheiro M. (1987). Frequency patterns in cochlear, brainstem and cerebral lesions. *Audiology* 26: 79-88.
- Musiek F, Pinheiro M, Wilson D. (1980). Auditory pattern perception in split brain patients. *Arch Otolaryngol* 106:610-612.
- Neff W. (1961). Neural mechanisms of auditory discrimination. In: Rosenblith W, ed. *Sensory Communication*. Cambridge, MA: MIT Press, 259-277.
- Noffsinger D, Wilson R, Musiek F. (1994). Department of Veteran Affairs compact disc recording for auditory perception assessment: background and introduction. *J Am Acad Audiol* 5:231-235.
- Pengilly L. (1992). *Normative Studies on the Auditory Duration Patterns Test*. Unpublished thesis, University of New Mexico, Albuquerque, NM.
- Pinheiro M. (1976). Auditory pattern perception in patients with right and left hemisphere lesions. *Ohio J Speech Hear* 12:9-20.
- Pinheiro M. (1977). Tests of central auditory function in children with learning disabilities. In: Keith R, ed. *Central Auditory Dysfunction*. New York: Grune and Stratton, 223-256.
- Pinheiro M, Godbey N. (1973). *Perceptual Reversals of Temporal Patterns with Co-Varying Acoustic Cues*. Presented at the annual meeting of the American Speech and Hearing Association, Detroit, MI, October, 1992.
- Pinheiro M, Ptacek P. (1971). Reversals in the perception of noise and tone patterns. *J Acoust Soc Am* 49:1778-1782.