Two Tests for Determining Sensitivity to Temporal Fine Structure:
The TFS1 Test and the TFS-LF test

Most of the sounds that we encounter in everyday life, including speech and music, are broadband; their spectra cover a wide range of frequencies. When such sounds are analyzed in the cochlea of a normal ear, the result is a series of bandpass-filtered signals, each corresponding to one position on the basilar membrane. Each of these signals contains two forms of information; fluctuations in the envelope (E, the relatively slow variations in amplitude over time) and fluctuations in the temporal fine structure (TFS, the rapid oscillations with rate close to the center frequency of the band). Information about the TFS is conveyed in the temporal patterns of firing in the auditory nerve, and it may play an important role in pitch perception, masking, and the perception of speech in background sounds.

Recent evidence suggests that people with cochlear hearing loss, and older people with or without hearing loss, have a reduced ability to process information carried in the TFS, and this contributes to their difficulties in understanding speech in the presence of background sounds. For a review, see

Moore, B.C.J. 2008. The role of temporal fine structure processing in pitch perception, masking, and speech perception for normal-hearing and hearing-impaired people. *J Assoc Res Otolaryngol*, DOI: 10.1007/s10162-008-0143-x.

http://dx.doi.org/10.1007/s10162-008-0143-x

The software that you can download from this website implements two tests for measuring sensitivity to TFS: the TFS1 test, which is usually conducted separately for each ear, and the TFS-LF test, which is a test involving use of both ears. The tests can be installed on a PC with a standard (good-quality) sound card. It is intended that sounds are delivered via headphones. Extensive help files come with the software.

The TFS1 test

The TFS1 test can be used to determine the sensitivity of an individual to TFS for centre frequencies above about 800 Hz. It was developed by Aleksander Sek and Brian Moore. Each ear is tested separately (the ear to be tested is selected in the software).

The method is based on that described in:

Hopkins, K., and Moore, B. C. J. (**2007**). "Moderate cochlear hearing loss leads to a reduced ability to use temporal fine structure information," J. Acoust. Soc. Am. **122**, 1055-1068.

but modified as described in:

Moore, B. C. J., and Sek, A. (**2009**). "Development of a fast method for determining sensitivity to temporal fine structure," Int. J. Audiol. **48**, 161-171.

The implementation is described in:

Sek, A., and Moore, B. C. J. (**2012**). "Implementation of two tests for measuring sensitivity to temporal fine structure," Int. J. Audiol. **51**, 58-63.

The task is to discriminate a harmonic complex tone (called H), with a fundamental frequency F0, from a tone in which all frequency components are shifted upwards by the same amount in Hz, ΔF, so as to create an inharmonic tone (called I). Both tones are passed through a fixed bandpass filter that is centred on the upper (unresolved) components. On each trial, there are two intervals and each interval contains four successive tones. For one of the intervals, selected at random, the four tones are H tones, giving the pattern HHHH. For the other interval, the four tones alternate between H and I, with a frequency shift of each component ΔF, giving the pattern HIHI. The task is to identify the interval in which the pitch of the tones varies. The value of ΔF is adjusted to determine the value that can just be detected.

A measurement for a single F0 and centre frequency takes about 2 minutes, and only a little training is required.

The TFS-LF test

The TFS-LF test is described in:

Hopkins, K., and Moore, B. C. J. (**2010**). "Development of a fast method for measuring sensitivity to temporal fine structure information at low frequencies," Int. J. Audiol. **49**, 940-946.

The implementation of the test is described in:

Sek, A., and Moore, B. C. J. (**2012**). "Implementation of two tests for measuring sensitivity to temporal fine structure," Int. J. Audiol. **51**, 58-63.

The task involves discrimination of the lateral position of sinusoidal tone bursts based on an interaural phase difference (IPD). The envelopes of the tones are synchronous across the two ears, so the task can only be performed if the listener is sensitive to IPD. The task can be used for frequencies below about 850 Hz. Even young listeners with normal hearing become insensitive to IPD for frequencies above 1500 Hz.

The task structure is similar to that for the TFS1 test. In each interval there are four successive tones. In one interval the tones are all in-phase at the two ears. For a person with symmetric hearing, these tones all appear to be at the same location within the head. In the other interval, tones 1 and 3 are in-phase at the two ears, but tones 2 and 4 have an IPD of Δφ, giving a pattern of IPD: 0 Δφ 0 Δφ. If the listener is sensitive to IPD, these tones appear to move within the head. The listener is asked to pick the interval in which the tones appear to move. The value of Δφ is adjusted to find the value that is just detectable.

A measurement for a single frequency takes about 2 minutes, and only a little training is required.

Use of the tests

The outcome of the TFS tests may be useful for the following purposes:

1) For those conducting research on hearing, the test may be useful for characterising the auditory abilities of individual hearing-impaired people, especially when a battery of tests is being administered.

2) For those involved in the clinical assessment and treatment of hearing-impaired people, the test may be useful for counselling a hearing-impaired client. A person with little or no sensitivity to TFS is likely to have

difficulty in understanding speech when background sounds are present, and a hearing aid may be of limited help.

3) The tests may provide early signs of dysfunction of the auditory system, for example associated with acoustic neuroma and mild auditory neuropathy.

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