ASA/ANSI S3.71-2019

AMERICAN NATIONAL STANDARD

Methods for Measuring the Effect of Head-worn Devices on Directional Sound Localization in the Horizontal Plane

Secretariat:

Acoustical Society of America

Approved on April 30, 2019:

American National Standards Institute, Inc.

Abstract

The methods described in this standard provide data which may be used for assessment of sound localization performance open ear and with head-worn devices using human subjects. The standard describes three measurement methods: 1) a low-complexity method using 8 loudspeakers to measure location discrimination performance; 2) a more complex, more robust method to measure localization error using 36 loudspeakers; and 3) a method to measure the functional impact of degraded localization cues on visual search time with 36 loudspeakers. The standard specifies subject qualification criteria, test space acoustic requirements, details of the three methods, and reporting requirements. The standard does not provide guidance for measuring localization performance for elevation or for clinical spatial audiometry.

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Accredited Standards Committee S3, Bioacoustics

Standards Secretariat
Acoustical Society of America
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Foreword

[*This Foreword is for information only and is not a part of the American National Standard ANSI/ASA S3.71-2019 Methods for Measuring the Effect of Head-worn Devices on Directional Sound Localization in the Horizontal Plane. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.*]

This standard comprises a part of a group of definitions, standards, and specifications for use in bioacoustics. It was developed and approved by Accredited Standards Committee S3 - Bioacoustics, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S3 is as follows:

> *Standards, specifications, methods of measurement and test, and terminology in the fields of psychological and physiological acoustics, including aspects of general acoustics which pertain to biological safety, tolerance and comfort.*

This standard is not comparable to any existing ISO Standard.

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Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S3 - Bioacoustics in care of the Standards Secretariat of the Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, New York 11747. Telephone: 631-390-0215; FAX: 631-923-2875; E-mail: asastds@acousticalsociety.org.

Introduction

Auditory situation awareness describes a person's use of auditory information, combined with other sensory information, to develop an understanding/awareness of their environment. Sound detection, distance estimation, sound localization, speech communication, and others, are commonly accepted components of auditory situational awareness. The importance of sound localization is relative to the situation and acoustical environment, and emphasis on this singular component must be balanced with other auditory needs.

Many head-worn devices can affect the accuracy and time needed for a user to localize a sound and thereby affect his/her auditory situation awareness. These devices include hearing protectors, hearing aids, headphones, helmets, etc. Additionally, new technologies are being developed and marketed that claim to provide the user with the ability to monitor the ambient acoustic environment and maintain sound localization cues while protecting the user from noise. Standards exist that specify methods for measuring the attenuation properties of hearing protection devices, but at the time of the approval of this standard, there were no existing standards that addressed the impact such devices have on the user's localization performance. The ability to localize sounds is critical in many occupations including firefighting, law enforcement, emergency response, military operations, and many others in which hearing protection and/or head-worn devices must be used. The objective of this standard is to establish methods that enable accurate, repeatable, and reliable measurement of sound localization performance for human listeners.

This standard describes a set of measurement protocols for quantifying the effect of a head-worn device on one hearing-critical task: sound localization in the horizontal plane. The presence of a head-worn device will change the sound field around the user's head, and will change the sounds reaching the user's eardrums. This may lead to changes in the user's performance on hearing critical tasks, such as speech communication, or the detection, localization, and identification of sounds in the user's environment. Some of these changes are by design; for example, a hearing protector is designed to attenuate hazardous sounds, and a hearing aid is designed to amplify quiet sounds that may have been inaudible to the user. Other changes are a side effect of wearing the device. A device may enhance performance on a particular task and degrade performance on a different task. When determining whether a device is appropriate for use in a particular situation, the effect of the device on all hearing-critical tasks should be weighted by the importance of those tasks for the situation.

This standard describes three methods to assess the effects of wearing head-worn devices on the user's localization performance. Method 1 uses four pairs of loudspeakers and data are collected with the listener oriented in each of two directions and should be viewed as a simplified procedure for estimating localization performance. It provides a measure of location discrimination performance as well as an estimate of the proportion of front-back reversals. Method 2 uses an array of 36 (10-degree spacing) loudspeakers in a sound-treated environment with a high-resolution (2-degree spacing or better) response metric to measure localization performance over the full horizontal plane. Method 2 samples the localization performance at the 36 defined loudspeaker locations. Method 3 uses the same dense array of loudspeakers as Method 2 with the addition of a small cluster of four LEDs at each loudspeaker to implement an aurally guided visual search procedure for assessment of the functional impact of degraded localization cues. Each of the methods captures differing aspects of localization performance and the effects of degraded localization cues from head-worn devices.

American National Standard

Methods for Measuring Directional Sound Localization in the Horizontal Plane

1 Scope

The methods described in this standard were designed to enable accurate, repeatable, and reliable measurement of sound localization performance with or without head-worn devices. The standard is based on fundamental localization measurement paradigms that have been used in numerous laboratories. Three measurement methods are described. Method 1 should be viewed as a simplified procedure for estimating localization performance. Method 2 should be used as a robust measure of localization performance with or without head-worn devices and should identify moderate to significant degradation of localization cues. Method 3 should be used as a measure of the functional impact of degraded localization cues. Each of the methods captures differing aspects of localization performance and the effects of degraded localization cues from head-worn devices. Data from measurements detailed in this standard can be used to describe the effects of head-worn devices on localization in the horizontal plane and can be used to assess the relative performance of subjects wearing head-worn devices compared to open-ear localization performance. Users of this standard include universities, manufacturers of hearing devices (e.g., hearing protectors, communication headsets, hearing enhancement with ambient listening capability, hearing aids), commercial test laboratories, and government laboratories.

The methods described in this standard are limited to measurements of human localization performance in the horizontal plane (azimuth) only and are not intended to be used for clinical spatial audiometry or for measuring localization performance in elevation. The methods are not intended to be used for measurement of sound localization performance of devices designed to determine the location of acoustic sources.

NOTE 1 Method 1 was intentionally designed to be relatively limited in sophistication to make it more accessible to users of the standard without requiring the resources necessary for using Methods 2 and 3.

NOTE 2 Auditory localization may improve over time for individuals who wear hearing protection or other head-worn devices more than occasionally. The localization results obtained using the methods described in this standard are intended to assess localization performance before auditory learning with a specific device has occurred over a period of hours or days. For additional guidance see 4.1.6.2, 4.1.6.3, and 8.1.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI/ASA S1.1, *American National Standard Acoustical Terminology*

ANSI/ASA S1.4-2014/Part 1/IEC 61672-1:2013*, American National Standard Electroacoustics – Sound Level Meters – Part 1: Specifications (a nationally adopted international standard)*

ANSI/ASA S1.11-2014/IEC 61260, Parts 1, 2, and 3, *American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters (nationally adopted international standards)*