Variations in the speed of sound and interaural differences of time: An additional source of jitter

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(Received 15 March 1991; revised 22 April 1991; accepted 21 May 1991)

Variations in the speed of sound result in interaural temporal uncertainty which may contribute to localization ambiguity at the extreme peripheral azimuths.

PACS numbers: 43.66.Qp, 43.66.Pn, 43.20.Hq [WAY]

The speed of sound depends on the characteristics of the medium within which it propagates (e.g., temperature, relative humidity, wind velocity). While it is obvious that interaural differences of time (IDT) are affected by such variations, the localization literature has generally not reflected on the magnitude and impact of such changes on angular acuity. Equation (1) (AIP, 1972) provides the speed of sound (V) in m/s in air as a function of temperature (t) in C°:

$$V = 20.06\ (273 + t)^{0.5}. \tag{1}$$

Translated into IDTs (Mills, 1972),

$$\mathrm{IDT}_{\mu s} = r(\Theta + \sin\Theta)/V \tag{2}$$

(where Θ is azimuthal displacement in radians, r is the width of the head in meters, and V is in m/μs), one can obtain angular shifts resulting from changes in temperature by first calculating several IDTs (for several V's) at one azimuth (e.g., 90°) and then recalculating the angle Θ relative to a referent speed (e.g., 331.5 m/s) for each value of the IDT (i.e., if the system is calibrated to only one velocity, how would it interpret the various IDTs?). For the most extreme case ($\Theta = 90°$) the calculated angular shift caused by a shift in t is plotted in Fig. 1 (assuming $r = 8$ cm). A 40 °C shift in temperature, therefore, may cause an angular ambiguity of about 9°. The ambiguity, of course, subsides as the source is displaced toward the sagittal midline. The effects of wind velocity are, in addition, vectorially additive to such calculations and result in IDTs that may change instantaneously. Perhaps, the poor localization acuity typically observed at the periphery (Mills, 1972) may be partially affected by such physical limitations of the acoustic environment.

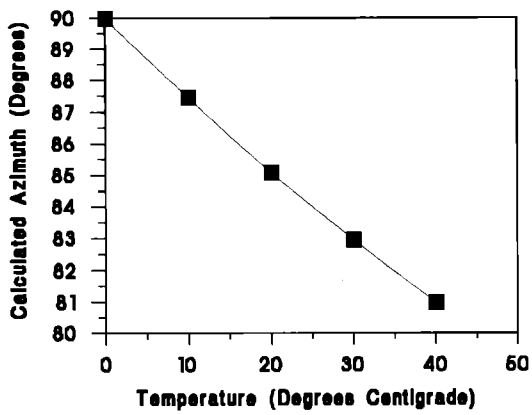

FIG. 1. Angular shifts calculated as a function of temperature for a sound source located at 90° azimuth referenced to $V = 331.5$ m/s.

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 0001-4966/91/091677-01$00.80