Stimulus-Frequency Otoacoustic Emissions As a Probe of Cochlear Tuning in the Common Marmoset

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Abstract

In this study, we compared the characteristics of SFOAE phase-gradient delays in marmoset to those in other species. Marmoset delays are significantly shorter than human and rhesus monkeys. This suggests that marmoset delay data can be used to estimate BM length. Marmoset data also confirm for the first time that age and species differences in BM length are closely related to the range of audible frequencies. Additionally, we report that marmoset SFOAE delays are comparable to or longer than those of domestic cat over 3+ octaves from 0.8-8 kHz, but similar above 8 kHz. Marmoset delays are shorter than those of domestic cat over 3+ octaves from 0.8-8 kHz, but similar above 8 kHz. Marmoset delays are significantly shorter than human and rhesus at all frequencies tested (Fig. 5).

Materials and Methods

SFOAE delays in marmoset are comparable to or longer than those in domestic cat (Fig. 5). Thus animals with shorter BMs do not necessarily have shorter SFOAE delays. Correlations between SFOAE delay and cochlear tuning established in other animals [Shera et al. 2002, 2010] suggest that marmoset cochlear tuning is comparable to or slightly sharper than in domestic cats. Correlations between the sharpness of cochlear tuning and the slope (mm/octave) of the cochlear map seen in other mammals [Shera et al., 2010] suggest that the slope of the marmoset map is similar to that of domestic cat. This is consistent with the fact that both the BM length and the frequency range of hearing in marmoset are smaller than in domestic cat (Fig. 1).

Results

No spontaneous OAEs were observed, consistent with the findings of Valero et al. (2008). Figure 3 shows the SFOAE magnitude and phases compiled across monkeys. SFOAEs were readily observable in all animals, each exhibiting a unique/reproducible pattern of magnitude peaks and valleys as the stimulus tone was swept. Magnitudes were smaller by approximately 5-10 dB over the range 1-6 kHz compared to human [Shera et al., 2008], domestic cat [Guinan, 1990], and rhesus monkey [Joris et al., submitted].

Discussion

Some differences in both magnitude (5-10 dB) and phase-gradient delay (0-0.5 ms) were apparent between probe types (ER-10C vs. 10A) and with age. However, these factors were not systematically examined in this study, nor independent of one another in the present data set. Thus, the trends shown in Fig. 4 are representative of all monkeys and probes. As such, the present data set cannot address sex differences previously reported for marmoset distortion-product OAEs [Valero et al., 2008].

Some phase curves have been offset vertically for clarity. The solid red curve in the magnitude plot shows the trend for all data that passed a 10 dB S/N ratio threshold, regardless of age. The solid blue curve in the phase plot indicates the integrated phase-gradient trend (from Fig. 4).

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References

[References are listed here.]

Figure 1 - Comparison of approximate audiometric ranges across species, as compiled by Heffner & Heffner (2007). These lines indicate the range of sensitivity at or below 60 dB SPL, while the thick line indicates the range at or below 10 dB SPL. The figure is newly derived from Heffner & Heffner (2007). Full details are included to avoid the marmoset [Osmanski & Wang, 2011].

Figure 2 - Example spectrograms of marmoset vocalizations. Note that energy appears primarily centered at 5-11 kHz, chiefly 5-15 kHz. The figure is adapted from Dallmeier & Wang (2006).

Figure 3 - Marmoset SFOAEs (magnitude and phase) measured at 40 dB SPL. Marmoset SFOAEs are comparable to or longer than those of domestic cat over 3+ octaves from 0.8-8 kHz, but similar above 8 kHz. Marmoset delays are significantly shorter than human and rhesus at all frequencies tested (Fig. 5).

Figure 4 - Marmoset SFOAE phase-gradient delays, computed from the phase curves shown in Fig. 3 a. The delay is the slope of the phase curves (cycles/Hz). Only points whose corresponding magnitude was at least 10 dB above the noise floor are shown [Shera & Bergevin, in preparation].

Figure 5 - Cross-species comparison of SFOAE phase-gradient delays in stimulus periods (Nsf). Data points and trends are shown for all species. Confidence intervals (e.g., Fig. 4) are not shown for clarity. Human and domestic cat data are from Shera & Guinan [2003], while the rhesus data are from Joris et al. [submitted], and were measured by the same paradigms and stimulus levels (40 dB SPL). The legend gives approximate BM lengths for each species.