THE EFFECT OF AGE AND STIMULUS PARAMETERS ON THE OPTIMUM f_2/f_1 RATIO FOR DPOAEs.

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Distortion Product Otoacoustic Emissions (DPOAE) are commonly used to study the pre-neural activity of the cochlea in adults and infants. The parameters used to generate the optimum DPOAE have been studied in adults (see Probst et al., 1991 for review). One of these parameters is the optimum f_2/f_1 ratio, this ratio between the primary tones can influence the maximum amplitude of the DPOAE. An early report indicated that the optimum f_2/f_1 ratio was 1.25 (Kemp & Brown, 1983). There has been agreement across studies that in adults the optimum f_2/f_1 ratio is approximately 1.2. Harris et al. (1989) found the optimum ratio to be 1.22, but they also described an inverse relationship between optimum f_2/f_1 ratio and the frequency of the DPOAE with larger ratios required at 1 kHz than at 4 kHz. In addition, they reported that the optimal ratio changed as a function of the intensity of the primaries in such as way as the intensity of the primaries increased, the ratio used to elicit a maximal DPE amplitude also increased. Although this ratio was from studies in the adult, it was used as the f_2/f_1 ratio when testing infants. Brown et al. (1994) investigated the optimum f_2/f_1 ratio at 2 and 4 kHz in term-born infants and found the ratio to be 1.2 which was in agreement with the optimum ratio for adults.

This study measured DPOAEs in 3 infant groups (30-33 wks.; 34-37 wks.; 38-42 wks.) and an adult group. Each group had 40 subjects with the exception of the youngest preterm group which only had 25 infants. DPOAEs were measured from one ear of each of the 145 subjects tested. Each subject was tested at six f_2 frequencies from 10 to 1.7 kHz in half octave steps. The f_2 tone is fixed at a given frequency and the f1 tone is swept around it from a ratio of 1.3 to 1.1. The optimum f_2/f_1 ratio is determined as the ratio between the two primary tones (f_2 and f_1) which creates the largest amplitude $2f_1$-f_2 (DPE) emission for a given f_2 frequency. The level of the primaries for all groups were 45 and 60 dB SPL for f_2 and f_1 respectively. In addition, the adult group also had DPOAEs measured at primary levels between 20 and 45 dB SPL (in 5 dB steps) for the f_2 frequency while keeping f_1-f_2 =15 dB.

We found that the dominant factor in determining the optimum f_2/f_1 ratio was the f_2 frequency and that there were no significant effects of age. The frequency effect showed that the optimum f_1 was relatively lower for lower f_2 frequencies (i.e. a higher f_2/f_1 ratio) and relatively higher for higher f_2 frequencies (i.e. a lower f_2/f_1 ratio).

The ratio becomes larger as the f_2 frequency decreases. There appears to be a natural break in the optimum ratio between 3.5 and 4.9 kHz. It is at this point (approximately 4 kHz) where the ratio changes, above and below this point the ratios are significantly different from each other. The optimum ratio above f_2 >4 kHz is smaller (1.18) than the ratio below f_2 <4 kHz (1.22). This is different than previous studies who reported a constant ratio across frequencies but consistent with Harris et al. (1989) who also noted an inverse relationship. This may be explained by the change in the shape of the excitation profiles along the BM. As indicated by tuning curves, the low frequencies are more broad tuned than high frequencies and change the slope of the profile at the apical end. The overlap on the BM associated with a particular ratio in the high frequencies will be different than in the low frequencies. These results indicate that the ratio is stable and that there is no effect of maturation. This suggests that cochlear excitation profiles, which are assumed to be responsible for that ratio are maturing early.

An adult group was used to study intensity effects on the optimum f_2/f_1 ratio. The results suggest a trend for lower optimum ratios for lower f_2 intensities. The effect of intensity on the optimum f_2/f_1 ratio revealed that as intensity increases the optimum ratio also increases, this occurred at all but two frequencies (f_2 = 3.4 and 7.0 kHz). As the intensity of the primary tones increases resulting in a broadening of the BM tuning, maximum overlap occurs at a lower f_1 frequency or a frequency further away from the f_2 frequency place. This occurs so that the maximum overlap will be maintained. There must be some balance for the two primary tones between overlap and suppression. Overlap of the two primary tones causes the largest non-linear interaction whereas suppression of one tone over another tends to reduce the importance of f_2 and also the emission.

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