INTRODUCTION

Lateral inhibition is a neural process which enhances the representation of contrasts. In the visual system, for example, the response levels of different receptors on the retina represent light intensity as a function of spatial location (visual contrast). Lateral inhibition serves to magnify differences in the response levels of cells encoding information about locations where light intensity changes (i.e., where there are edges). Since the encoding of contrasts seems to be common to all sensory modalities, von Bekesy (1967) argued that a process to enhance contrasts could, should, and does operate in all sensory systems.

Evidence of lateral inhibition in the central auditory system was available to von Bekesy (early work by Galambos and Davis, 1944; von Bekesy cites Suga, 1965), however, data consistent with the peripheral process which he hypothesized were not reported until after his book entered publication. Such data demonstrate a reduction in the response to one stimulus when one simultaneously presents a second stimulus (the suppressor) under appropriate conditions. These reductions, termed suppression effects, have been observed directly through physiological measures of the response of the auditory nerve (e.g., Sachs and Kiang, 1968) and indirectly through psychophysical measures which are believed to depend upon the response of the peripheral auditory system (e.g., Houtgast, 1972).

The identification of conditions in which one could demonstrate suppression effects led to a great deal of research through the 1970s. There is very good agreement between the physiological and psychophysical measures and effects seen with both are attributed to a common process: suppression. Although it soon became clear that suppression and lateral inhibition operate through different mechanisms (suppression does not involve inhibitory synapses as lateral inhibition does), the two processes were accepted as sharing a common function, facilitation of sensory analysis through the enhancement of contrasts. In the auditory system, suppression would serve to enhance spectral contrasts: Differences in the levels of response in cells responding to different frequencies would be enlarged wherever there were 'dips' or 'peaks' in the spectrum. Presumably this enhancement would be manifest as an increase in frequency
selectivity and seen, among other ways, as an increase in the Qs of the auditory filters with which the ear performs a spectral analysis of auditory signals. The purpose of this paper is to review (with an emphasis on psychophysical data) the arguments and evidence for suppression as a spectral enhancement process and, in light of recent data, suggest that there is not strong evidence that the role of suppression is to enhance frequency selectivity.

THE NEED FOR AN ENHANCEMENT PROCESS

The frequency selectivity that von Bekesy (1960) reported to be present in the response of the basilar membrane was poorer than that observed in the response of auditory nerve fibers. It was reasonable for von Bekesy to argue that lateral inhibition was responsible for this improvement. However, as measurement techniques have improved, the frequency selectivity reported to be present in the basilar membrane response has also improved. Today, it appears that the discrepancy between the basilar membrane and auditory nerve responses is very much less than von Bekesy observed, and may not exist at all (e.g., Khanna and Leonard, 1982). Although the exact degree of tuning in the basilar membrane remains controversial, these new data cast doubt on the supposition that normal frequency selectivity on the basilar membrane is poor so that some enhancement process (suppression) is necessary to improve the response of the membrane.

Suppression also has been invoked to account for an apparent improvement in frequency selectivity when one compares psychophysical measures obtained in forward masking conditions to those obtained in simultaneous conditions. As a phenomenon, masking refers to the elevation in the threshold for one stimulus (the signal) caused by the presence of another stimulus (the masker). Forward masking is an elevation in threshold which occurs when the masker presentation precedes the signal presentation. It typically is attributed to a reduction in the response to the signal due to adaptation in the auditory nerve. In turn, this adaptation is caused by the excitatory response of the nerve during the masker presentation. Simultaneous masking is an elevation in threshold which occurs when masker and signal are present at the same time. It is often attributed to a competition of the response to the signal with the on-going response to the masker. However, other processes, including suppression, operate during the simultaneous presentation of stimuli. One argument (e.g., Wightman et al., 1977) is that simultaneous masking estimates of frequency selectivity arise from a mixture of excitatory processes and suppression both acting to reduce signal detectability, whereas forward masking estimates represent the results of excitatory processes only. Given that suppression is active for moderate frequency separations, and assuming that two masking processes are more effective than one, lower masker levels will be required to mask a given signal in simultaneous masking than in forward masking. Thus there will appear to be greater frequency selectivity in the forward masking measures and the difference between simultaneous and forward masking measures will be due to suppression.

Some problems arise when one more carefully considers the idea that two masking processes are better than one. First, for both suppression and excitatory processes to operate on the signal, the masker would have to produce an excitatory effect. Examination of Figure 1 shows that this would occur only if the masker level were close, if not equal, to the level found when only excitatory processes operate. Contrary to the data, this predicts that only small differences could occur between simultaneous and forward masking. Second, for both processes to operate,