1. INTRODUCTION

The functioning of the auditory system can be described as performing with a certain time constant, a frequency analysis of the incoming signals. Such an analysis means that frequency selectivity and time resolution are closely linked. It has led in practice to the use of narrow-band signals for the determination of the frequency selectivity and of wide-band signals (noise or clicks) for the determination of the temporal acuity. The use of such signals avoids the interactions as much as possible and makes it difficult to determine the effects of frequency selectivity and temporal resolution on each other.

One of the ways to determine the time resolution, is the measurement of the aftereffects of a stimulus. Many authors have described post masking experiments for a variety of masker and probe signals in which masked thresholds were determined as a function of the time delay between masker and probe. The probe level is thought to represent the level of activity or sensitivity caused by the masker that is still present after the specific time delay. A decay or recovery curve can thus be estimated.

Some authors have used tone bursts for the two signals in order to restrict the frequency region. Spectral splatter may affect the measurements and the interpretation of the data may be affected by cueing phenomena (Terry and Moore, 1978; Moore, 1980) and off-frequency listening (Verschuure, 1981; Johnson-Davies and Patterson, 1979). Most authors use the same frequency for masker and probe. The measured patterns show the decay at that particular frequency, but not how frequency selectivity and time resolution interact. The interaction can be seen in postmasking patterns, measured for various time delays (Fastl, 1979; Bechly and Fastl, 1982).

It is the purpose of this paper to determine the interaction between frequency selectivity and time resolution by measuring pulsation patterns with silent intervals inserted between pulsator and probe. The advantage of the technique is the relatively long probe duration, which minimizes the splatter, the absence of cueing and the fact that Verschuure (1981) has established a relationship between pulsation patterns and the underlying excitation pattern. We therefore know when off-frequency listening is of importance.

2. METHODS

We determined input and output pulsation threshold patterns (Verschuure, 1981) with silent intervals inserted between pulsator and probe. The duration of pulsator and probe was always kept constant at 125 ms. The signals were switched with smoothing envelopes. It is a gaussian amplitude envelope with a time constant of 3.55 ms. The duration of signals and gaps is defined as the time between the half-amplitude points. The equipment has been described by Verschuure et al. (1976).

Four experienced observers participated in the experiments, but none of them did all the experiments. Data will be shown on individual observers. The validity of the data is checked by others who did not do the extensive measurement.

The rationale behind the experiment is the same as the one presented by Plomp (1964). The pulsator evokes a distribution of activity in the auditory system. This excitation pattern will decay after the pulsator is switched off. It is not important at this point whether it is a decay of activity or a recovery of sensitivity. The probe builds up another excitation pattern. It is assumed that the probe is heard as continuous only if there is no significant drop in activity level in any channel stimulated by the probe, during the time the probe is off (Houtgast, 1974;
Verschuure, 1981). This means that the excitation pattern of the probe must be fully contained within the decayed excitation pattern of the pulsator. This interpretation takes off-frequency listening into account and the nonlinearity with level. The use of various gap durations will show how the excitation pattern decays, both with the course of time and in the frequency domain.

3. RESULTS AND DISCUSSION

a) Pattern of decay

Observer MB measured input and output extension patterns at 0.5, 1.0 and 2.0 kHz for different pulsator levels and for a number of gap durations. An example of an input extension pulsation pattern at 1.0 kHz for a level of 65 dB SPL is given in fig. 1 for gap durations of 0, 20, 40, 50 and 60 ms.

![Input extension pulsation patterns at 1 kHz, 65 dB SPL](image)

Three frequency regions have to be distinguished:
- In the upper high-frequency region a parallel downward shift of the pulsation pattern is found.
- The shift in the lower high-frequency region is characterized by a gradual reduction of the slope of the shallow edge to the pattern. In certain instances this has even led to a shift of the maximum probe level to a higher frequency than the pulsator frequency. This is particularly found for the very high pulsator levels of about 80 dB.
- The decay of the low-frequency edge results again in a more or less parallel shift of the pulsation pattern.

Postmasking patterns of Fastl (1979) can be interpreted in very much the same way except that the parallel shift in the upper high-frequency region is not clear because data points are not available in this region. The patterns of Bechly and Fastl (1982) for gaps longer than 20 ms are very similar to ours.

Verschuure (1981) has shown that the high-frequency edge to the pulsation pattern represents the high-frequency edge to the excitation pattern. Off-frequency detection could not take place because the slope of the excitation patterns gets less steep with level. This means that the high-frequency edge to the excitation level of the probe is less steep. It implies that the high-frequency edge to the pulsation patterns of fig. 1 reflects the edge to the excitation pattern. The observed pattern change reflects a change in the distribution of auditory activity. The low-frequency edge to the pulsation patterns does not reflect the excitation pattern. This slope gets steeper with level so the slope of the probe excitation