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# Effect of signal delay on auditory detection with gated uncorrelated noise

**W. A. WILBANKS**
*University of Georgia, Athens, Georgia 30602*

**An uncorrelated noise more effectively masks a monaural signal when the noise is gated simultaneously with the signal than when the noise is continuous. As the onset of the signal is delayed, detection in gated noise does not differ from that found with continuous noise. This is in agreement with an earlier study on the effect of signal delay on detection with gated monaural and correlated noise. The results are interpreted in terms of Jeffress' classical approach to signal detection theory.**

Several investigators have reported that gated noise may produce more masking of tonal signals than continuous noise at the same spectral level. In an earlier study (Wilbanks, 1967), we showed that if the noise and the signal are not gated simultaneously, that is, if the onset of the signal is delayed re the onset of the noise, the effect of noise gating diminishes to the point at which there is virtually no difference between detection with continuous and gated noise. In that study, a monaural signal was used, and the noise was presented monaurally at the signal ear (NM-SM) and binaurally with a correlation of +1.00 (NO-SM). As the onset of the signal was delayed, binaural detection improved quite rapidly. Monaural detection improved with signal delay, but at a slower rate. McFadden (1966) found little difference between continuous and gated noise when both signal and noise were gated simultaneously and presented in phase at both ears (NO-SO). However, if either the signal or the noise (but not both) were reversed in phase by 180 deg, McFadden found that a gated noise was about 5-6 dB more effective in masking the signal than was continuous noise. As in our study, McFadden reported that if the onset of the signal in either case was delayed re the onset of the noise, the effect of noise gating diminished. The interesting thing about these two studies is that the greatest improvement in detection with gated noise that occurs when the onset of the signal is delayed seems to occur under those conditions in which binaural detection is superior to monaural, that is, under those conditions in which binaural masking-level differences (MLDs) are found. If this is the case, the effect of signal delay on detection with gated noise should be minimal under those conditions in which there is no advantage of binaural over monaural detection. In the present study, we examine the effect of signal delay on detection with gated noise with a correlation of zero (NU).

## METHOD

The signal, a 250-Hz pure tone, was presented monaurally at the listener's more sensitive ear. The duration of the signal (50 msec) was controlled by an Iconix electronic counter that triggered a Grason-Stadler switch, gating the signal with a 10-msec rise-fall time.

The signal was partially masked by a wide-band noise cutoff at the lower end by the response of the earphones (TDH-49) and at the upper end by a 3,000-Hz low-pass passive filter. The spectral level of the masker, measured at 250 Hz across the earphones with a Hewlett-Packard wave analyzer, corresponded to approximately +45 dB re .0002 microbar/cycle. The noise was presented binaurally with a correlation of zero. The zero correlation (NU) was achieved by using independent noise generators, one for each ear. Both continuous and gated maskers were used. The duration of the gated noise (200 msec) was controlled by the same electronic counter that controlled the duration of the signal. The counter triggered a Grason-Stadler switch that gated the noise with a 10-msec rise-fall time. For the gated noise condition, the onset of the signal was delayed re the onset of the noise by 0, 25, 50, 75, 100, 125, and 150 msec.

The detectability of the signal was determined by means of a two-alternative temporal forced-choice (2AFC) method. The signal was programmed to occur at random in one or the other of two temporal intervals marked for the listener by lights. With the gated noise, the observation interval lights always coincided with the time of the signal onset and offset, and not with the onset-offset of the noise. This was done to reduce the uncertainty of the listeners as to the time of signal presentation (Egan, Greenberg, & Schulman, 1961). The listeners were informed that the a priori probability of the signal's occurring during the first interval was .50.

Three well trained listeners were used, two men and one woman. Since they were experienced with 2AFC experiments, no special instructions were required, and no system of trial-by-trial informational feedback was employed.

For each experimental condition, five signal levels, separated by equal-decibel steps, were used. Psychometric functions were then obtained relating percentage correct choices to signal level. The correction for response bias suggested by Egan (1965) was used. From these psychometric functions, the main dependent variable was determined: the signal level in decibels required for 85% correct choices.

## RESULTS AND DISCUSSION

The results are presented in Tables 1 and 2. Table 1 gives signal level in decibels for 85% correct choices as a function of signal delay in milliseconds and interaural condition. In Table 2, masking in decibels by gated noise re continuous noise is given as a function of signal delay in milliseconds and interaural condition.

Table 1
**Signal Level in Decibels for 85% Correct Detections**

| Signal Delay | NU-SM | NM-SM | NO-SM |
|---|---|---|---|
| 0 | 66.0 | 66.2 | 57.0 |
| 25 | 65.7 | 65.9 | 54.1 |
| 50 | 65.4 | 65.8 | 54.0 |
| 75 | 65.5 | 65.6 | 53.8 |
| 100 | 65.2 | 65.3 | 53.3 |
| 125 | 64.7 | 64.9 | 53.0 |
| 150 | 64.3 | 64.6 | 52.7 |
| CN | 61.5 | 61.9 | 52.0 |

*Note–Signal delays are given in milliseconds. CN = continuous noise.*

Table 2
**Masking in Decibels by Gated Noise re Continuous Noise**

| Signal Delay | NU-SM | NM-SM | NO-SM |
|---|---|---|---|
| 0 | 4.5 | 4.3 | 5.0 |
| 25 | 4.2 | 4.0 | 2.1 |
| 50 | 3.9 | 3.9 | 2.0 |
| 75 | 4.0 | 3.7 | 1.8 |
| 100 | 3.7 | 3.4 | 1.3 |
| 125 | 3.2 | 3.0 | 1.0 |
| 150 | 2.8 | 2.7 | .7 |

*Note–Signal delays are given in milliseconds.*

With an uncorrelated masker (NU), gating the noise so that its onset is synchronous with that of the signal (0-msec delay) reduces the detectability of the signal by about 4 dB. There is a slight improvement in detection as the onset of the signal is delayed re that of the noise. When the offset of the signal is synchronous with that of the noise (150-msec delay), a gated uncorrelated noise results in about 1 dB more masking than a continuous noise. The difference between NU-SM and NM-SM across conditions is negligible. This is what would be expected, since Blodgett, Jeffress, and Whitworth (1968) and Wilbanks and Whitmore (1968) have shown that NU-SM is basically a monaural condition.

In the case of NO-SM, a gated correlated noise reduces the detectability of the signal by about 5 dB when the onset of the signal occurs simultaneously with the onset of the noise. With a signal delay of 150 msec, the difference between gated and continuous correlated noise is negligible.

The results with gated uncorrelated noise are consistent with our earlier findings: A gated noise is more effective than a continuous noise when its onset is synchronous with that of the signal.

It is important to note that detection is about 9-10 dB better under all conditions with NO than with NU or NM. This MLD agrees very closely with that reported by Blodgett et al. (1962), Whitmore and Wilbanks (1965a, 1965b), and Wilbanks and Whitmore (1968). These results have been consistently confirmed by many other investigators.

It is now pretty clear that the basis for detection is some sort of transformation of the noise distribution when the signal is added. In terms of the classical approach to detection theory taken by Jeffress (1964, 1972, Note 1), detection is based upon some difference between a sample of noise (N) and signal plus noise (S + N). For monaural detection and detection with uncorrelated noise, the difference between N and S + N appears to be one of amplitude. The basis for detection with NO, according to Jeffress' vector model, is the change in the correlation of the noise when the signal is added. Our results show that noise gating degrades detection when the change in N due to the onset of the signal (S + N) is minimal, that is, when the signal and noise are gated simultaneously.

## REFERENCE NOTE

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