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**THE IMPACT OF MASKER FRINGE AND MASKER SPARIAL UNCERTAINTY
ON SOUND LOCALIZATION**

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14. ABSTRACT Signal-in-noise detection improves when the masker duration extends beyond that of the signal ("masker fringe") relative to the case in which the signal and masker are pulsed on/off simultaneously. This improvement has been attributed to the fact that the fringe provides a baseline set of stimulus parameters that serves as a context against which a signal may be detected. Conversely, when the fringe parameters are inconsistent with those of the masker, signal detectability may be reduced. In this study, the impact of masker fringe on sound localization is examined. The results demonstrate the importance of stimulus parameters prior to and subsequent to the portion of the stimulus containing the signal for sound localization.					
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The Impact of Masker Fringe and Masker Spatial Uncertainty on Sound Localization

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1 Introduction

Several studies have shown that the threshold for a signal presented in noise may be reduced when the masking noise is turned on prior to the signal onset (forward masker fringe) and/or the noise is turned off subsequent to the signal offset (backward masker fringe) relative to the case in which the signal and masker are pulsed on and off simultaneously [1,2]. It has been argued that this masker fringe provides a baseline set of stimulus parameters against which the signal may be more easily detected [3,4]. A slightly different, but related, explanation would suggest that the fringe provides the listener with information about the parameters of the masker occurring during the signal interval - that is, the fringe reduces masker uncertainty. This interpretation may be related to studies on informational masking where it has been shown that providing a 'preview' (e.g., through cuing) of the spectral components of a masker improves performance on a signal detection task, presumably as a result of reduced masker uncertainty (e.g., [5]). It is possible that forward masker fringe provides a similar preview of the masker characteristics and it is the reduction in masker uncertainty afforded by this preview that leads to a release from masking. Conversely, a masker fringe that provides no information, or misleading information, about the masker may in fact disrupt performance. Recent results have also demonstrated the impact of spatial uncertainty on signal detection [6] and speech intelligibility [7]. The goal of this study was to determine the impact of various configurations of masker fringe and masker spatial uncertainty on sound localization and to examine how such effects might be related to binaural detection and informational masking.

2 Methods

2.1 Participants

Six listeners (three male, three female), ages 20-25 years old, were paid for their participation in this experiment. All had normal hearing (i.e., thresholds < 15 dB above audiometric zero from 125 Hz to 8000 Hz) and all had previously participated in studies on sound localization.

2.2 Apparatus

The study was conducted in the Auditory Localization Facility at the Air Force Research Laboratory at Wright-Patterson Air Force Base. This facility consists of a geodesic sphere (4.3 m in diameter) with 277 full-range loudspeakers mounted on its surface. The sphere is housed within an anechoic chamber, the walls, floor, and ceiling of which are covered in 1.1-m thick fiberglass wedges. For this study, only those loudspeakers above -45° in elevation were utilized. Mounted on the front of each loudspeaker is a cluster of four light-emitting diodes (LEDs).

2.3 Stimuli

The target to be localized was a 100-Hz, random-phase click train, with a bandwidth from 0.2 to 14.5 kHz and a duration of 60 ms, with 5-ms cosine-squared on/off ramps. The level of the target was 63 dB SPL when measured at the center of the sphere, and the location of the target was varied from trial to trial. The masker was a Gaussian noise burst with the same bandwidth and duration as the target, and was presented at 60 dB SPL. The masker and target had simultaneous onsets and offsets. The masker fringe consisted of bursts of Gaussian noise, each with a structure identical to that of the masker. The bursts were presented sequentially such that there were no temporal gaps between the offset of one burst and the onset of the next. The fringe occurred prior to the masker (forward masker fringe), subsequent to the masker (backward masker fringe) or both prior to and subsequent to the masker. In some cases, all fringe pulses came from the same location as the masker (fixed masker fringe); in other cases, each fringe pulse came from a different, randomly-selected location (random masker fringe).

In Experiment 1, only the fixed masker fringe condition was employed and the effect of fringe duration on sound localization was examined. In Experiment 2, each portion of the masker fringe (forward and backward) was composed of four pulses, and various combinations of fixed and random fringes were employed. In addition, in some cases, the forward or backward masker fringe was absent (a "Quiet" portion of the stimulus). In each experiment, only one

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condition was tested within a block of trials. See Figure 1 for a graphical representation of the general form of the stimulus employed.

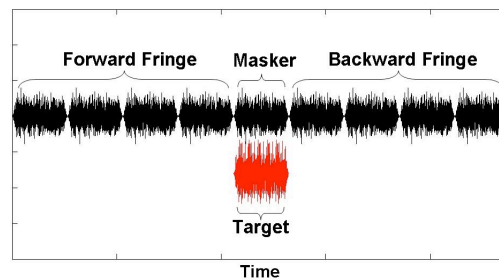


Figure 1. Experimental stimulus

2.4 Procedure

Listeners stood on a platform in the Auditory Localization Facility with their head positioned in the center of the sphere. At the beginning of each trial, the listener was required to orient toward the loudspeaker at 0° azimuth, 0° elevation, and remain in a fixed position during the stimulus presentation. After the stimulus presentation, listeners were required to point a hand-held tracking device at the perceived target location and depress a button on the device to record the localization response. Trial-by-trial feedback was provided by activating the LED cluster at the actual target location.

3 Results

The results from Experiment 1 are shown in Figure 2. Here, the overall angular localization errors, averaged across all listeners, are plotted as a function of the duration of the masker fringe (both forward and backward) when the fringe is presented from the same location as the masker (fixed). As can be seen, localization errors decrease systematically as the duration of the forward and backward fringes are increased from 0 to 240 ms. Of note is the fact that even 60 ms of forward and backward fringe leads to a substantial reduction in localization errors relative to the case in which the masker and target are pulsed on and off simultaneously. These data are, in general, consistent with the results from the binaural detection literature and suggest that a longer duration fringe provides a more robust context against which to judge the location of the target.

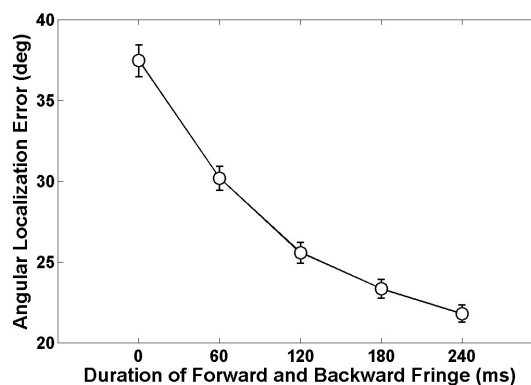


Fig. 2. Angular localization errors plotted as a function of the duration of forward and backward masker fringe. Error bars indicate ± 1 standard error.

The results from Experiment 2 are shown in Figure 3. The three-letter designation under each bar refers to the parameters of the masking stimulus in the format [forward fringe][masker][backward fringe]. [M] refers to the *masker*; [F] refers to a fringe in which all pulses are presented from a *fixed* location that is the same as the masker; [R] refers to a fringe in which individual fringe pulses are presented from *randomly*-selected locations. The letter [Q] stands for *Quiet*, a portion of the stimulus in which no fringe or masker is presented. The black bar in the second panel of Figure 3 represents the condition in which the target and masker are pulsed on and off simultaneously (the ‘No Fringe’ condition), replotted from Figure 2. The bars in the first panel indicate conditions in which masker fringe enhances performance relative to the ‘No Fringe’ condition. As can be seen, localization errors are reduced by up to 18° when a

forward fringe is presented at the masker location. Moreover, localization errors in the forward masker fringe condition (FMQ) are roughly 13° lower than errors in the backward masker fringe condition (QMF). This result is consistent with results from the binaural detection literature, which suggest that forward masker fringe provides a greater benefit than backward masker fringe [2]. The bars depicted in the third panel of Figure 3 indicate conditions in which the masker fringe degrades performance. As can be seen, the addition of a random masker fringe nearly always leads to greater errors than the those found for the ‘No-Fringe’ condition. Moreover, the negative effects of adding a random *backward* fringe are more severe than the effects of adding a random *forward* fringe.

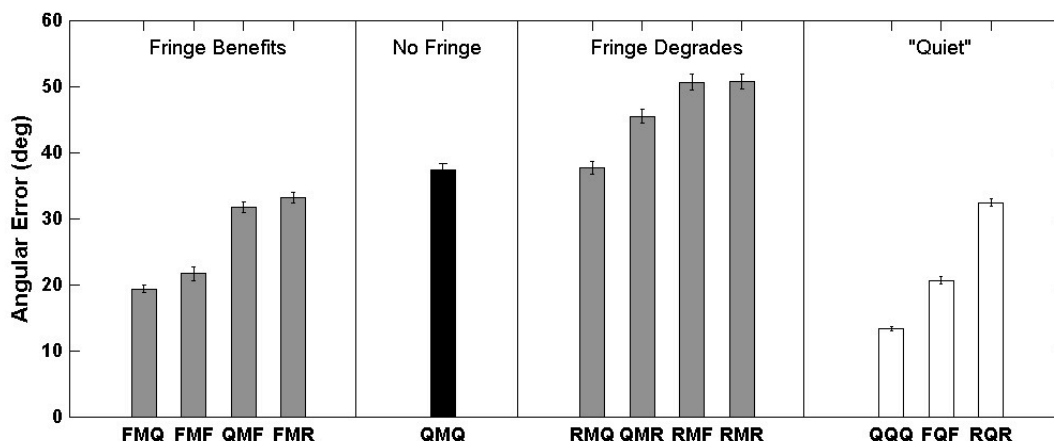


Fig. 3. Overall angular errors, averaged across listeners, plotted in each condition examined. Error bars represent +/- 1 standard error

The results in the rightmost panel of Figure 3 (“Quiet”) are conditions in which there is no masker during the signal interval. The increase in errors seen when the fringe is presented suggests that the fringe itself may act like a masker. One possible explanation is that temporal integration could lead to the fringe being averaged in with the target interval, thus reducing the effective signal-to-noise ratio and making it more difficult to recover the localization cues associated with the target. However, the large degradation in performance seen when the target is preceded and followed by a *random* masker fringe (the RQR condition) as compared to the *fixed* masker fringe (FQF) suggests that this effect is at least in part due to the random fringe acting as a informational masker, directly interfering with a listener’s ability to recover spatial cues.

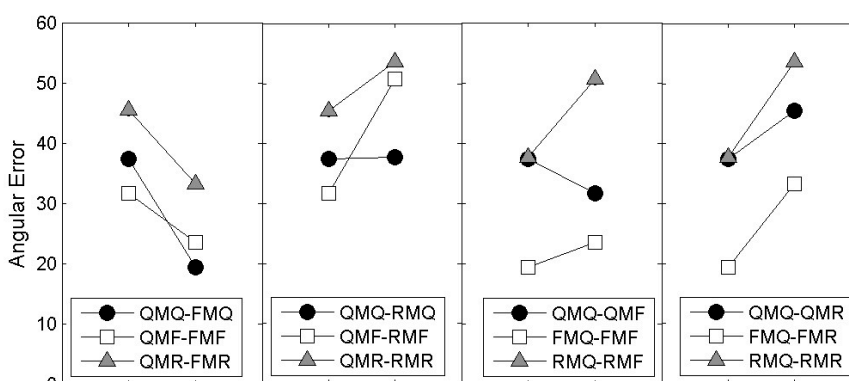


Fig. 4. In each panel, a comparison is made between a given stimulus condition and that condition with a specific forward or backward masker fringe added.

The effect of adding various forward and backward masker fringes is depicted more directly in Figure 4. In each panel, one type of fringe (fixed or random) is added to each of three conditions. In the first (leftmost) panel, a fixed-location forward fringe is added. As can be seen, adding this type of fringe to any stimulus configuration in the experiment always leads to a substantial reduction in localization errors, suggesting that this type of fringe effectively facilitates localization. In contrast, the results in the fourth panel indicate that the addition of a random-location backward fringe always results in a substantial *increase* in localization errors, suggesting that this type of fringe

somehow disrupts a listener's ability to recover localization cues. The effects of adding a random forward fringe (second panel) or a fixed backward fringe (third panel) are less consistent across stimulus conditions, though there is some evidence that having a quiet portion after the target interval leads to better performance.

4 Conclusions

The results from Experiment 1 suggest that a masker fringe with interaural parameters consistent with the masker provides information that a listener can use to improve localization performance relative to the case in which a target and masker are pulsed on and off simultaneously. Moreover, the benefit of this fringe increases as the duration of the fringe increases, consistent with results from the binaural detection literature.

The results from Experiment 2 indicate that both forward and backward masker fringe lead to improved localization performance when the fringe parameters are consistent with those of the masker (the fixed fringe conditions). Furthermore, in these cases, a forward masker fringe more effectively facilitates performance than does a backward fringe. Conversely, when masker fringe is presented from a location (or locations) that are different from that of the masker (the random fringe conditions), the fringe provides no benefit for localization and in some cases may actually disrupt localization performance. In this context, the random fringe seems to function as an informational masker. The fact that this random fringe causes more informational masking when it occurs after the target (backward fringe) is consistent with the suggestion by [8] that a backward informational masker is more effective than a forward informational masker.

In general, the results of this study suggest that having information about the characteristics of the masker can improve performance in a localization-in-noise task. To the degree that masker fringe provides this information, these results appear to be consistent with the results of [5], who showed that providing a preview of the masker was the most effective means of cuing in a signal detection task. The suggestion that cuing the masker allows a listener to establish a "rejection filter" to minimize the interference caused by the masker [9] could be applicable in this situation, where a listener would apply such a filter to a region of space associated with the masker. A random masker fringe does not afford the listener an obvious region to which such a filter should be applied. The overall results suggest that the effects of masker fringe are complicated, but it appears that some insights may be gained by considering these results within the context of the binaural detection literature as well as more recent work in informational masking.

References

- [1] McFadden DM "Masking-level differences with continuous and with burst masking noise," *J. Acoust. Soc. Am.* 40:1414-1419 (1966)
- [2] Trahiotis C, Dolan TR, Miller TE "Effect of 'backward' masker fringe on the detectability of pulsed diotic and dichotic tonal signals," *Percept & Psychophys* 12:335-338 (1972)
- [3] Yost, WA "Prior stimulation and the masking-level difference," *J. Acoust. Soc. Am.* 78:901-907 (1985)
- [4] Gilkey RH, Simpson BD, Weisenberger, JM "Masker fringe and binaural detection," *J. Acoust. Soc. Am.* 88:1323-1332 (1990).
- [5] Richards VM, Neff DL "Cuing effects for informational masking," *J. Acoust. Soc. Am.* 115:289-300 (2004)
- [6] Fan WL, Streeter TM, Durlach NI "Effect of spatial uncertainty of masker on masked detection for nonspeech stimuli," *J. Acoust. Soc. Am.* 124: 36-39 (2008)
- [7] Kopco N, Best V, Carlile S "Localizing a speech target in a multitalker mixture," *J. Acoust. Soc. Am.* 125:2691 (2009)
- [8] Pollack I (1975). "Auditory informational masking," *J. Acoust. Soc. Am.* 57:S5
- [9] Durlach NI, Mason CR, Kidd G, Arbogast TL, Colburn HS, Shinn-Cunningham BG "Note on informational masking (L)" *J. Acoust. Soc. Am.* 113:2984-2987 (2003)