#971 Contextual Effects in the Identification of Nonspeech Auditory Patterns in Random Maskers

Gerald Kidd Jr., Virginia Richards*, Timothy Streeter, Christine Mason and Rong Huang*

Hearing Research Center & Department of Speech, Language & Hearing Sciences, Boston University, Boston, MA

*Department of Cognitive Sciences, University of California Irvine, Irvine, CA

BOSTON UNIVERSITY

UNIVERSITY of CALIFORNIA IRVINE

INTRODUCTION

• Various forms of *context* can improve the reception and processing of target sounds. For example:
  • For detection, the "*enhancement effect*" (Viemeister, 1980) has been shown to significantly improve performance in masked conditions.
  • Under high stimulus *uncertainty*, the benefits of *cuing* the target or, the masker can provide large reductions in masked thresholds (Richards and Neff, 2004; Richards et al., 2004).
  • In speech perception, contextual effects can influence phoneme category boundaries, emphasizing *spectral contrasts* in sequences of speech sounds (Holt, 2005).
• Contextual effects appear to reflect *general auditory processing* abilities that are manifested across a wide range of auditory and speech perception tasks.
• Many questions remain about context effects. In this study, a nonspeech pattern identification task is used to examine context effects and to help clarify the stimulus conditions and task demands under which they are most beneficial. The target sounds are presented in highly uncertain listening conditions producing large amounts of *informational masking*.

METHODS

• 10 listeners age 21-27 yrs with normal hearing
• 1I, 6AFC tonal pattern identification task (see schematic for 6 patterns)
• Masker: 8 tonal sequences (see schematic)
  • Frequency bands chosen randomly on every trial (from set of 16)
  • Individual tone frequencies within the band chosen randomly
  • Level for the band chosen randomly from 0 to -20 dB re target level
• Baseline target condition is random frequency (1 of 4 bands)
• "Cues" (a priori information or context)
  • Fixed target frequency
  • Ipsilateral exact masker cue
  • Ipsilateral noise (notched for target area) cue
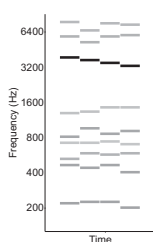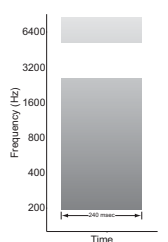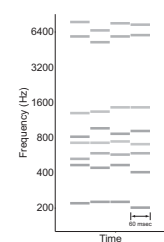 • Contralateral exact masker cue
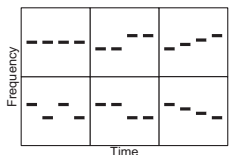
6 Target Patterns / Uncued/Cued Trials
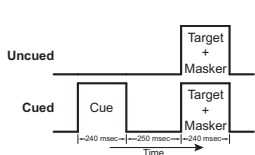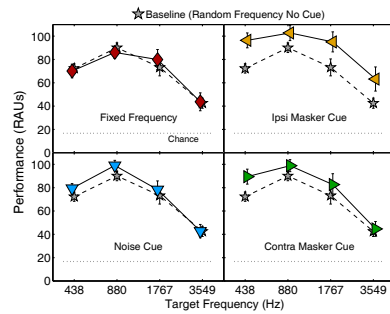

### Masker Cue / Noise Cue / Target + Masker

RESULTS

• Each panel shows one cue type in addition to the baseline condition (gray stars)
• Performance is expressed in rationalized arcsine units (RAUs) due to ceiling effects
  • Group mean performance averaged over target frequencies and listeners is not significantly different from baseline in the fixed frequency case (upper left panel)
  • The exact-masker cue provides substantial benefit on average at all target frequencies (upper right)
  • The noise cue provides a small benefit except at the highest target frequency (lower left)
  • A exact masker cue presented contralaterally provides more benefit than the noise cue but less than the ipsilateral masker cue (lower right)
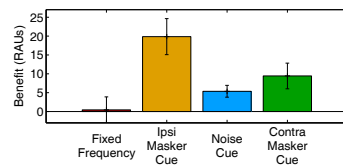
• Bars show average benefit (performance in each of the four cue cases minus baseline performance) over listeners and target frequencies.
  • Fixed frequency benefit is 0.4 RAUs.
  • Ipsi masker benefit is 19.8 RAUs.
  • Noise benefit is 5.4 RAUs.
  • Contra masker benefit is 9.4 RAUs.
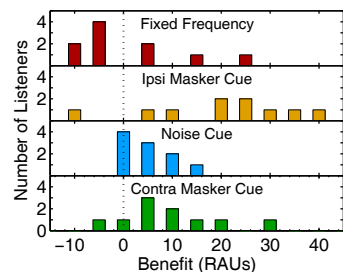
• Individual listeners vary in the amount of benefit averaged over the target frequencies and binned in 5 RAU steps.
  • In the Fixed Frequency case, 6 listeners show a decrease in performance while 4 improve.
  • For the Ipsi Masker Cue, 9 of the 10 listeners show benefit with 7 in the 20 RAU or more bins, and one listener shows a decrease in performance.
    • The largest benefit in any condition is seen here with 2 listeners in the 35 or 40 RAU bins.
  • In the Noise Cue case, 6 listeners show some benefit
  • For the Contra Masker Cue, 8 of the 10 listeners show some benefit.

• 2-way repeated measures ANOVA on individual listener RAU-transformed data revealed significant effects of:
  • Condition (baseline, fixed freq, ipsi cue, noise cue, contra cue) [$F_{(4,36)}=8.81$, $p<0.001$]
  • Target frequency [$F_{(3,27)}=22.87$, $p<0.001$] and,
  • the interaction [$F_{(12,108)}=2.05$, $p<0.05$]].

• Post-hoc tests of simple differences indicated that:
  • the fixed-frequency target condition was not significantly different than the baseline condition ($p=0.91$),
  • the ipsilateral exact-masker cue ($p=0.003$), notched-noise masker cue ($p=0.008$) and contralateral masker cue ($p=0.021$) conditions were significantly different from baseline.

• Paired t-tests of the average benefit for each of the 10 listeners revealed a significant difference between the ipsi cue and noise cue ($p=0.018$), the ipsi cue and contra cue ($p=0.029$) and no difference between the noise cue and contra cue ($p = 0.161$).

DISCUSSION

• No benefit was found for reducing target frequency uncertainty.
  • This finding is puzzling given past research that did show advantages for cuing target frequency under high informational-masking conditions (cf. Richards and Neff, 2004).
    • One possibility is that the benefit of a priori target information depends on the nature of the task. Previous work finding a target-cue advantage was for a detection task, while the current work is for above-threshold pattern identification in which the entire sequence must be processed and compared to memory.

• Of the types of a priori information tested, the greatest benefit was found for an ipsilaterally presented exact copy of the masker (about 20 RAUs) preceding the trial. This cued masker advantage could have at least two explanations:
  • adaptation of excitation or inhibition due to differential stimulation of target and masker frequency regions (enhancement), or
  • higher-level processing based on the spectrotemporal correspondence of cue and masker, possibly through reduction in uncertainty or spectrotemporal differencing.

• The notched-noise cue which tested the "enhancement" hypothesis, provided a small (about 5 RAUs) but significant advantage overall.

• The contralateral cue, which was unlikely to produce enhancement, provided a larger benefit (about 10 RAUs) than the notched-noise cue and is consistent with reduction in uncertainty and/or some other form of computational processing.

• These findings suggest that *both* enhancement, and the correspondence between the cue and masker, may contribute to the contextual benefits found here.

REFERENCES

• Holt, L.L. (2005) "Temporally nonadjacent nonlinguistic sounds affect speech categorization," Psychol. Sci., 16, 305-312
• Kidd, G. Jr., Mason, C.R. and Arbogast, T.L. (2002) "Similarity, uncertainty and masking in the identification of nonspeech auditory patterns," J. Acoust. Soc. Am., 111, 1367-1376
• Richards, V.M. and Neff, D.L. (2004) "Cuing effects for informational masking," J. Acoust. Soc. Am., 115, 289-300
• Richards, V.M., Huang, R. and Kidd, G. Jr. (2004) "Masker-first advantage in cues for informational masking," J. Acoust. Soc. Am., 116, 2278-2288
• Viemeister, N.F.(1980) "Adaptation of masking," in *Psychophysical, Physiological and Behavioral Studies in Hearing*, G. van den Brink and F.A. Bilsen (eds), Noordwijkerhout, The Netherlands, pp.190-198
• Viemeister, N. F. and Bacon, S. P. (1982) "Forward masking by enhanced components in harmonic complexes," J. Acoust. Soc. Am., 71, 1502-1507

ACKNOWLEDGEMENTS