Does random temporal jitter reduce onset dominance in temporal weighting functions for high-rate click trains? (1pPP3)

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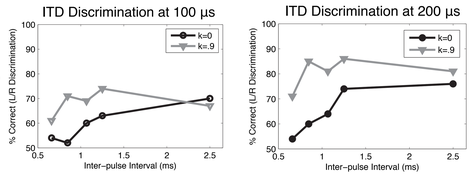
Introduction

Evidence for improved ITD discrimination with "jittered" pulse trains
- -Laback and Majdak (2008) - ITD discrimination in bilateral CI users improves with randomization of IPI for high-rate pulse trains (>=800 pps) interpreted by authors as "restarting" effect (Hafter and Buell., 1990)
- -Van Hoesel (2008) - "Restarting" explanation inconsistent with lack of benefit at 400 pps; occasionally longer IPIs and reduced ambiguity of post-onset cues (Freyman et al., 1997) provide better explanation

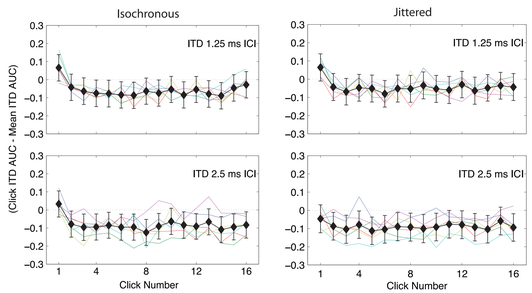
Temporal weighting in sound localization
- -Saberi (1996), Brown & Stecker (2009) - Temporal weighting functions (TWFs) indicate that laterlization of high-rate click trains in normal hearing listeners is dominated by onset (moreso in ITD than ILD)
- -Van Hoesel (2008) - higher weighting of post-onset cues in TWFs for ITD pulse trains correlated with better discrimination performance in a previous study using same listeners (Van Hoesel, 2007)

Binaural adaptation predicts effect of jitter on TWFs for ITD and ILD click trains
- -Hafter et al. (1983a, 1983b, 1987) - Binaural adaptation degrades ITD and ILD discrimination comparably, restarting observed for both cues (Hafter and Buell, 1990), suggesting a mechanism common to both
- -Hypothesis that a release from binaural adaptation accounts for benefit of "jitter" (Laback and Majdak, 2008) predicts that jitter will act to reduce onset dominance for both ITD and ILD in high-rate click trains in normal hearing listeners (although the mechanism of adaptation may differ) between populations

At right: Replotted from Laback and Majdak (2008)



Jitter Reduces Onset Dominance in ITD



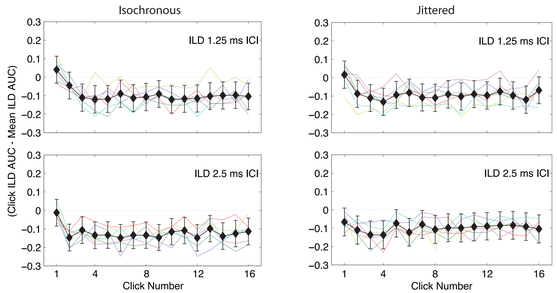
Above: Area under ROC curve (AUC) for click ITD relative to AUC for mean ITD. Distance from mean (0) at click 1 taken as "advantage of onset." Colored traces plot individual subject data; bold trace plots data with 95% confidence intervals averaged across subjects.

-Isochronous condition: Onset ITD more predictive of response than mean ITD at 1.25 and 2.5 ms ICI (advantage of onset ~.07 and ~.04, respectively)

-Jittered condition: Onset ITD remains more predictive than mean ITD at 1.25 ms ICI (advantage of onset ~.06); mean ITD becomes more predictive than onset at 2.5 ms ICI (advantage of onset ~-.05)

-Rate x jitter interaction suggested, tested below right

Jitter Reduces Onset Dominance in ILD



Above: Area under ROC curve (AUC) for click ILD relative to AUC for mean ILD. Distance from mean (0) at click 1 taken as "advantage of onset." Colored traces plot individual subject data; bold trace plots data with 95% confidence intervals averaged across subjects.

-Isochronous condition: Onset ILD more predictive of response than mean ILD at 1.25 ms ICI (advantage of onset ~.04); mean ILD more predictive than onset ILD at 2.5 ms ICI (advantage of onset ~-.01)

-Jittered condition: Onset ILD remains more predictive than mean ILD at 1.25 ms ICI (advantage of onset ~.02); (dis)advantage of onset increased to ~-.07 at 2.5 ms ICI

-Rate x jitter interaction and main effect of cue type suggested, tested below

Summary and Conclusions

- Interaction between rate and jitter - onset dominance reduced at 2.5 ms, but not 1.25 ms ICI ; contradicts finding of Laback and Majdak (2008) in bilateral CI users, where benefit was absent at 400 pps (2.5 ms IPI) but present at 800 pps (1.25 ms IPI)

-Evidence for reduced onset dominance in both ITD and ILD at 2.5 ms ICI, as expected based on release from binaural adaptation hypothesis (Hafter and Buell, 1990)

-Marginally significant difference between ITD and ILD mean advantage of onset at 2.5 ms ICI in isochronous condition is obscured or eliminated when jitter is introduced, consistent with the notion of mechanism for jitter benefit that impacts both

-Observed effects of jitter may be consistent with peripheral representation of ITD and ILD in high-rate click trains; gammatone filter simulation yeilds comparable modulation spectra for classic "restart" gap train and jittered train, with added low-frequency energy facilitative of binaural comparison in both cases

-Restart at high-rates may be affected by changes in peripheral modulation arising from the increased spectral density of jittered high-rate stimuli, offering reconciliation of Laback and Majdak's (2008) and Van Hoesel's (2008) interpretations

-Obvious limitation: The present results reflect normal hearing sensitivity and acoustic stimulation, where the motivating results reflect electrical stimulation; the mechanisms of adaptation and representation of modulation cues introduced by jitter are thus different in the two cases. Future manipulations may enable more direct comparisons.

Methods

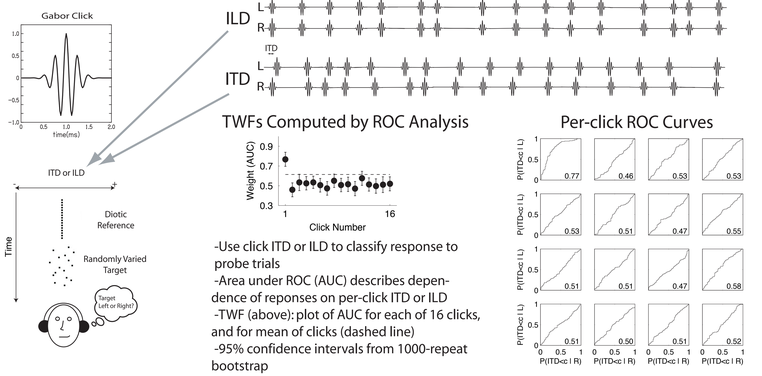
Subjects
-6 normal hearing listeners

Stimuli
-Trains of 16 Gabor clicks (cosine multiplied by Gaussian window)
- -4 kHz carrier frequency, 2 ms nominal duration/click (BW ~900 Hz)
- -Inter-click interval (ICI) of 1.25, 2.5; isochronous and jittered conditions
- -Isochronous condition employed static ICI (k=0)
- -Jittered condition employed ICI drawn from uniform distribution about ICI w/ width ±.9(ICI) (k=.9)

-2 intervals per trial
- -Fixed diotic reference
- -ILD or ITD target

-Randomly varied ITD or ILD per click in target interval
- -Independent click ILD/ITD drawn from uniform distribution about the midline (+/- 2 dB ILD, +/-100 us ITD)

Task
-2AFC, target left or right of diotic reference
- -100 trials/run - 60 probe trials, 40 "catch" trials with shifted distribution
- -4 runs/condition, 8 conditions (3200 trials)



-Use click ITD or ILD to classify response to probe trials
-Area under ROC (AUC) describes dependence of reponses on per-click ITD or ILD
-TWF (above): plot of AUC for each of 16 clicks, and for mean of clicks (dashed line)
-95% confidence intervals from 1000-repeat bootstrap

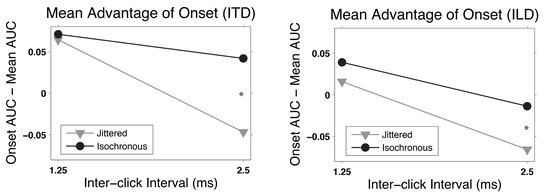
Significance of Rate x Jitter and Cue Type

-Omnibus 2x2x2 RM ANOVA indicates significant rate x jitter interaction F(1,5)=6.85, p<.05 (see summary at right)

-Paired t-tests using Bonferroni procedure indicate jitter is effective at 2.5 ms ICI for both ITD and ILD, t(5)=3.21, p<.025; t(5)=5.29, p<.025, but not at 1.25 ms ICI, p>.025

-Difference between advantage of onset for ITD and ILD present at 2.5 ms ICI in isochronous condition, t(5)=2.64, p<.05, is absent in jittered condition, t(5)=.60, p=.57

Source	*F(1,5)*	*p*
Cue	5.927	.059
Rate	82.622	**<.001**
Jitter	5.64	.064
Cue*Rate	.007	.937
Cue*Jitter	.128	.735
Rate*Jitter	6.848	**.047**
C*R*J	.450	.532



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