

Effects of binaurally-linked dynamic range compression on word identification by hearing-impaired listeners

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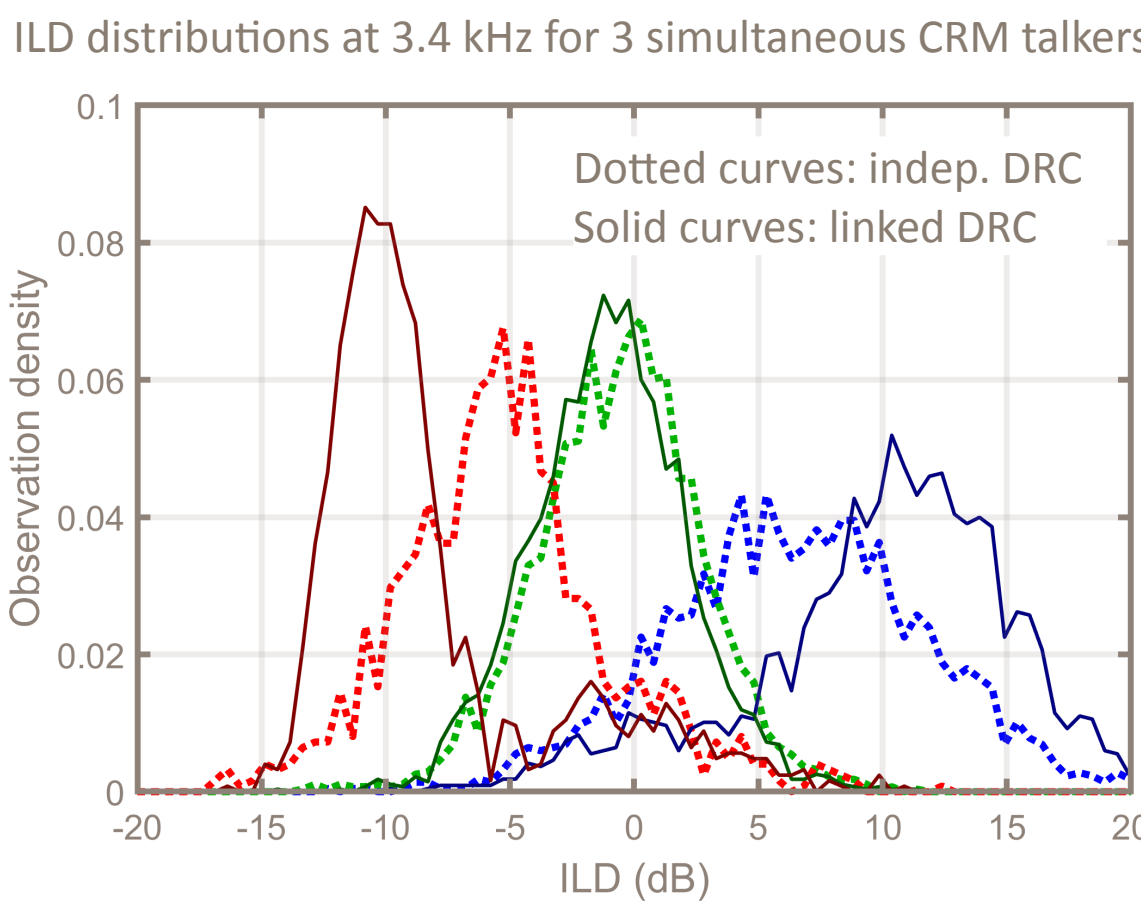
Background

- Relatively few previous studies on [speech perception](#) with binaurally-linked dynamic range compression (DRC)
- Schwartz and Shinn-Cunningham (2013): [normal-hearing](#) (NH) listeners identified dig-its in presence of interfering digits spoken by the [same voice](#) with and without reverb; DRC linking improved performance by about 10%
- Wiggins and Seeber (2013): NH listeners listened to sentences from front in presence of [speech-shaped noise from the side](#) (60°); DRC linking improved performance by about 10% due to improvement in better-ear SNR
- Arweiler (2011) using *average* gain of left and right did not observe linking benefits

→ Present experiments:

- [HI listeners](#) used [hearing-aid \(HA\) prototypes](#) with indep. and wirelessly linked DRC
- performed word identification in presence of [symmetrically-placed interfering talkers](#)
- assessed effects of [DRC linking](#), [early reflections](#) and number of [segregation cues](#)

Hypothesis: Better word identification with linked than independent DRC by preserving [interaural level difference](#) (ILD) cues in situations with few other segregation cues or in the presence of single early reflection

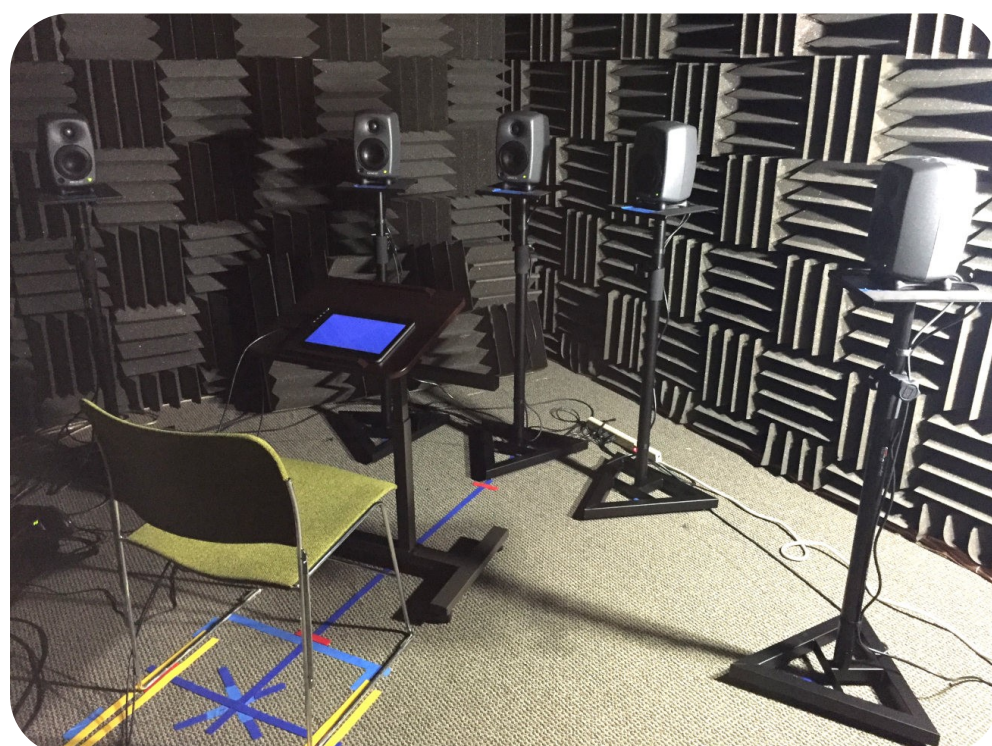


Experiment 1: Full cue CRM with and without reflection

Methods

- [12 HA users](#) recruited from Heuser clinic (ages 57 to 76 yrs, median 65 yrs)
- HA prototypes (RIC 312) with Power domes
- Linked DRC used [minimum of left and right gains](#) in 20 channels
- ANSI time constants: 12 ms attack, 54 ms release
- Same [NAL-NL2](#) gain prescription for all listeners (based on blue audiogram above)
 - Lower compression ratios (by factor 0.8), lower max gain, and lower gain (by 1 dB on average and 3 dB on lower signal percentiles) for linked DRC than for indep. DRC
- Coordinate response measure (CRM; Bolia et al., 2000), [four different, random female voices](#)
- [Sequential](#) sentences at 65 dB each, target from front:

-60°, voice A: “Ready Tiger go to White Two now.”
-20°, voice B: “Ready **Baron** go to **Red Five** now.”
0°, voice C: “Ready Laker go to Blue One now.”
20°, voice A: “Ready Ringo go to Green Six now.”
60°, voice D: “Ready Eagle go to Red Eight now.”

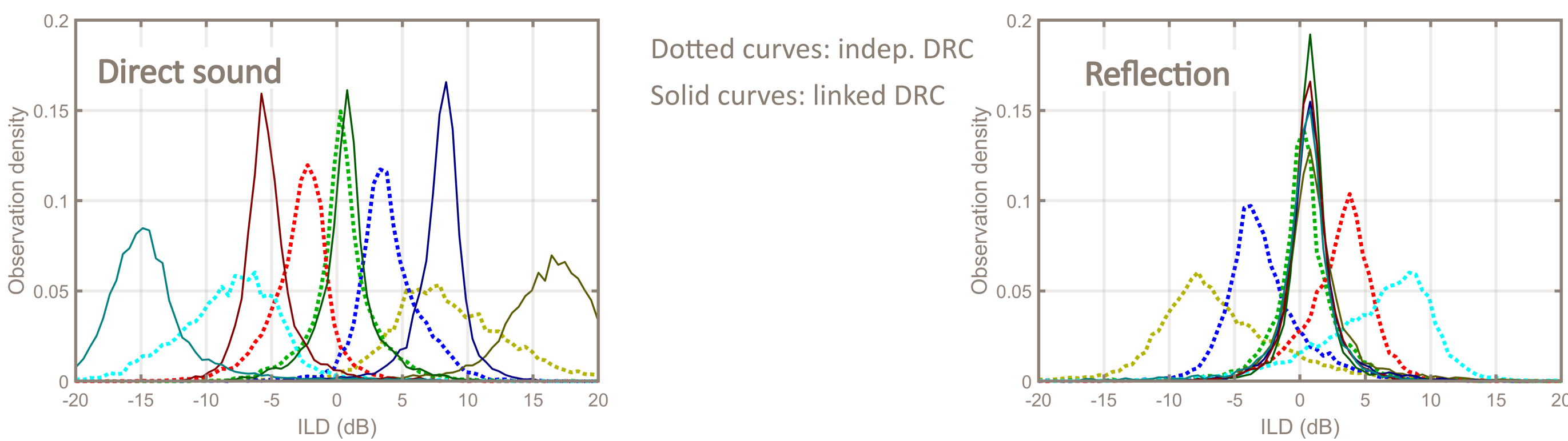


- Four counterbalanced conditions: Indep. and linked DRC, with and without [single reflection](#) applied to all talkers, but presented from 0°, att. by 10 dB, 20 ms delay

Results

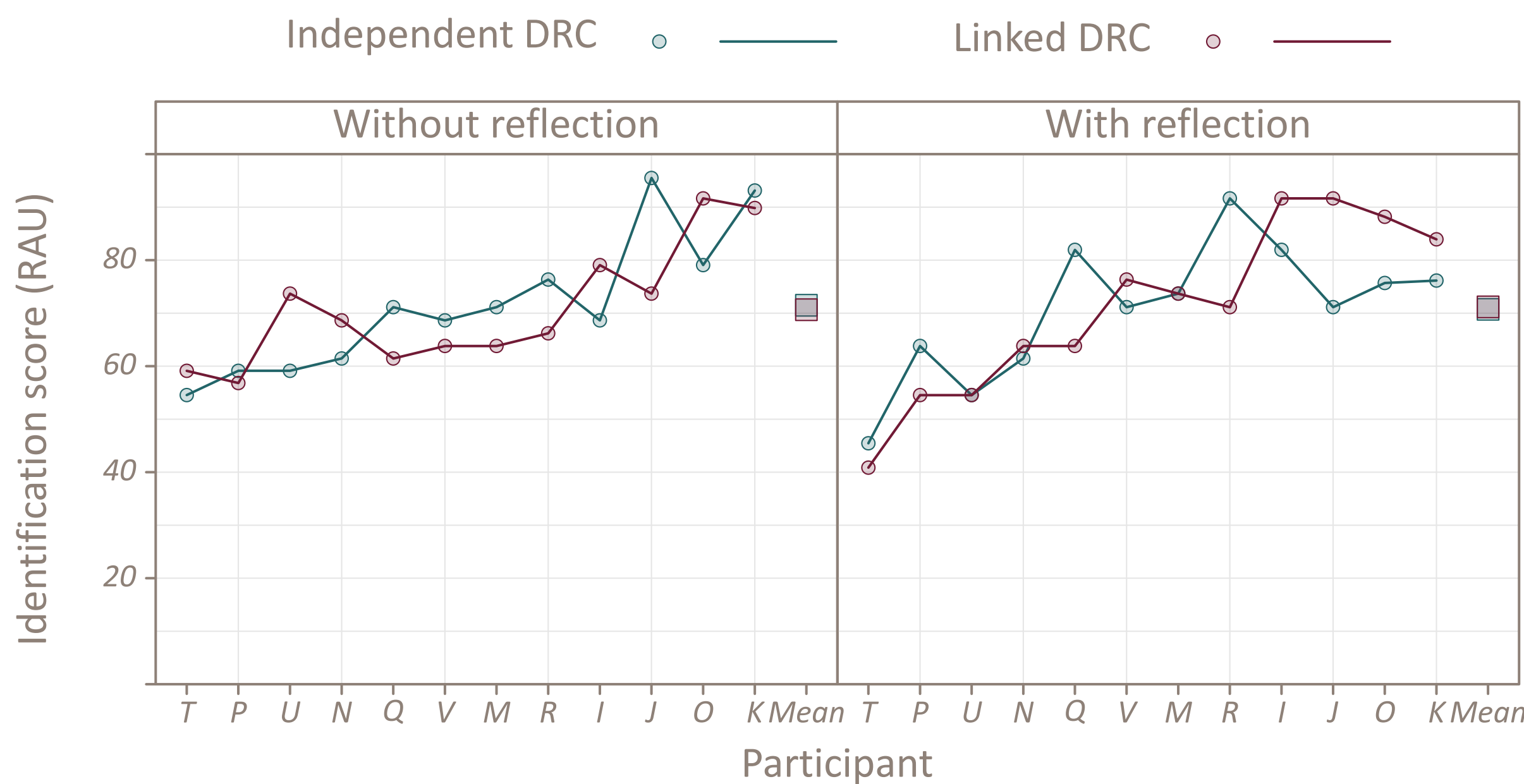
[Effect of DRC on reflection](#) via Hagerman method (Hagerman and Olofsson, 2004):

ILD distributions at 2.9 kHz for 5 sequential talkers (direct sound and reflection)



→ Independent DRC [pushes early reflections to opposite side](#) of direct sound, as gain is controlled by direct sound

Identification scores:



→ [No effects](#) of DRC linking nor of reflection

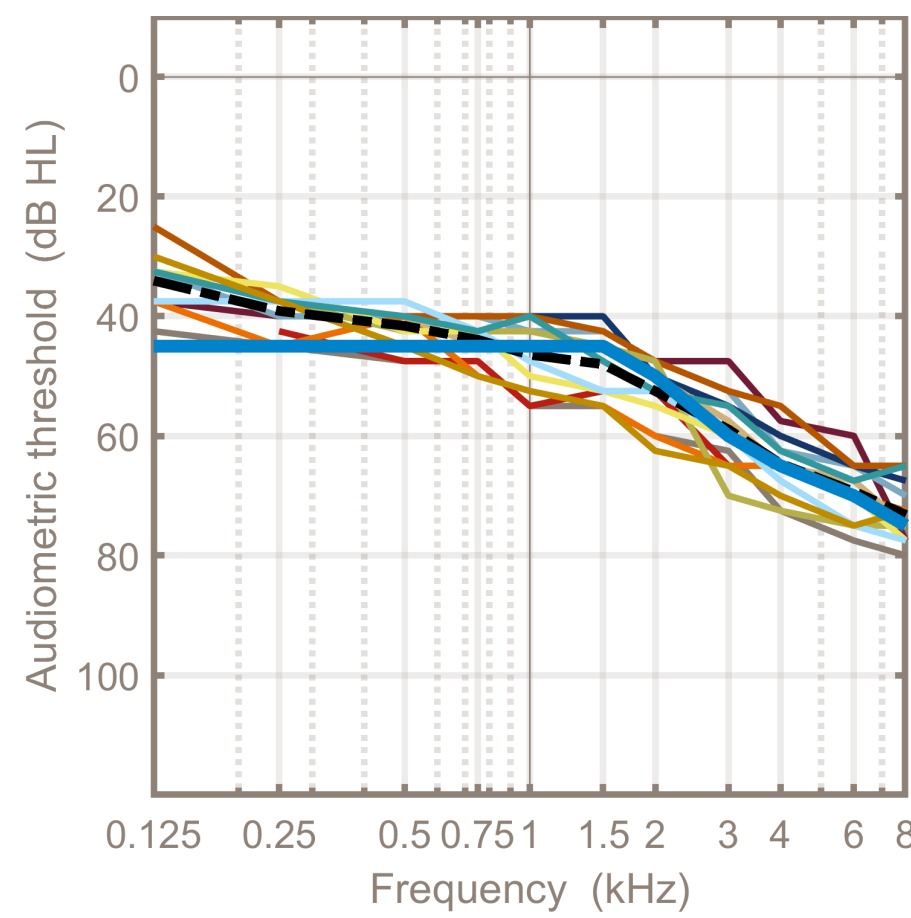
→ Scores not correlated with age or PTA

Experiment 2: Minimal cue (high-pass filtered and same voice)

Methods

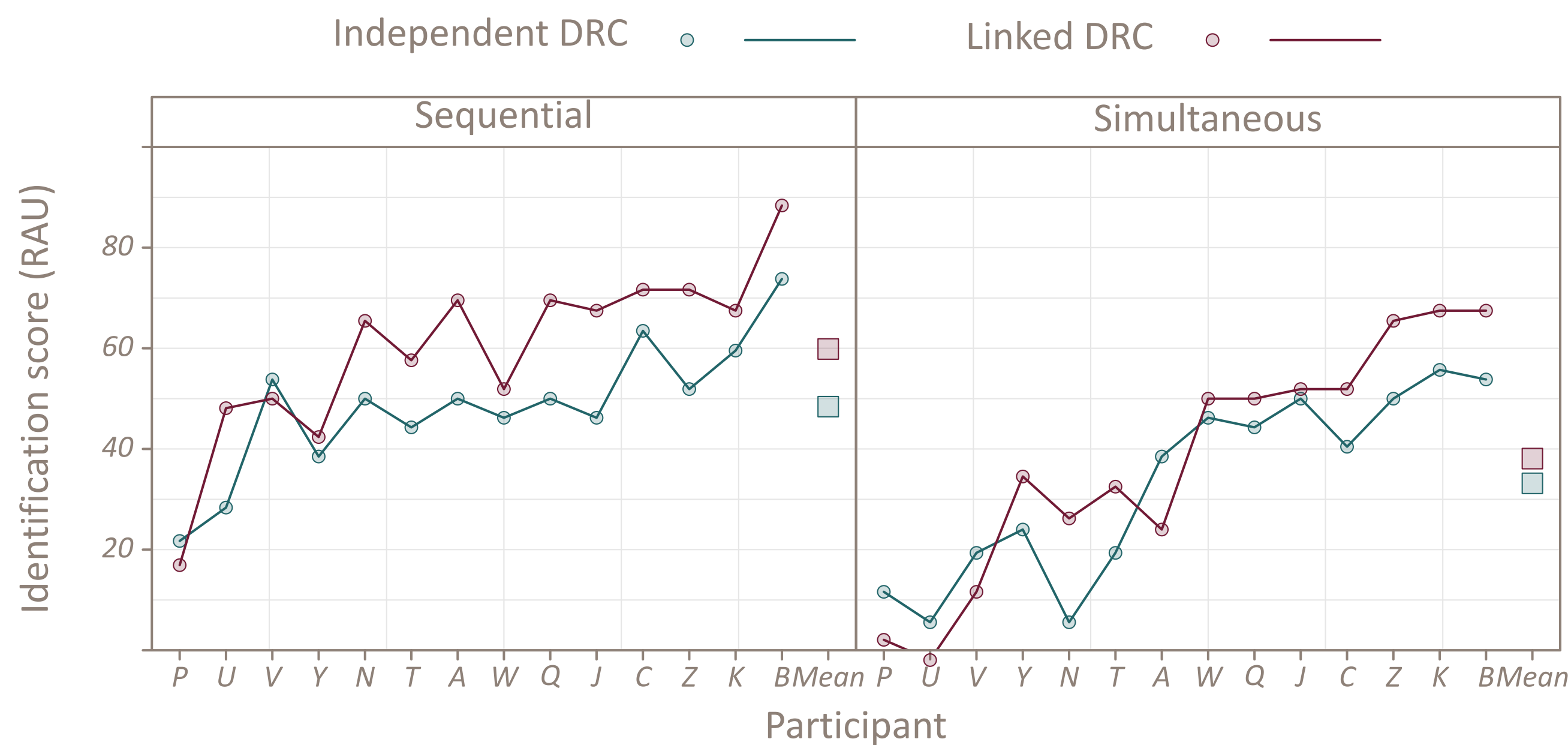
- Same as Exp. 1, except for the following
- [14 HA users](#) (eight returned; ages 56 to 77 yrs, median 70 yrs)
- All CRM sentences [high-pass filtered](#) at 1 kHz
- Four conditions: Indep. and linked DRC, sequential with [single voice](#) and simultaneous with two different female voices

Simultaneous CRM presentation: -60°, voice D: “Ready Tiger go to White Two now.”
0°, voice B: “Ready **Baron** go to **Red Five** now.”
60°, voice D: “Ready Laker go to Blue One now.”



Results

Identification scores for high-pass filtered CRM:



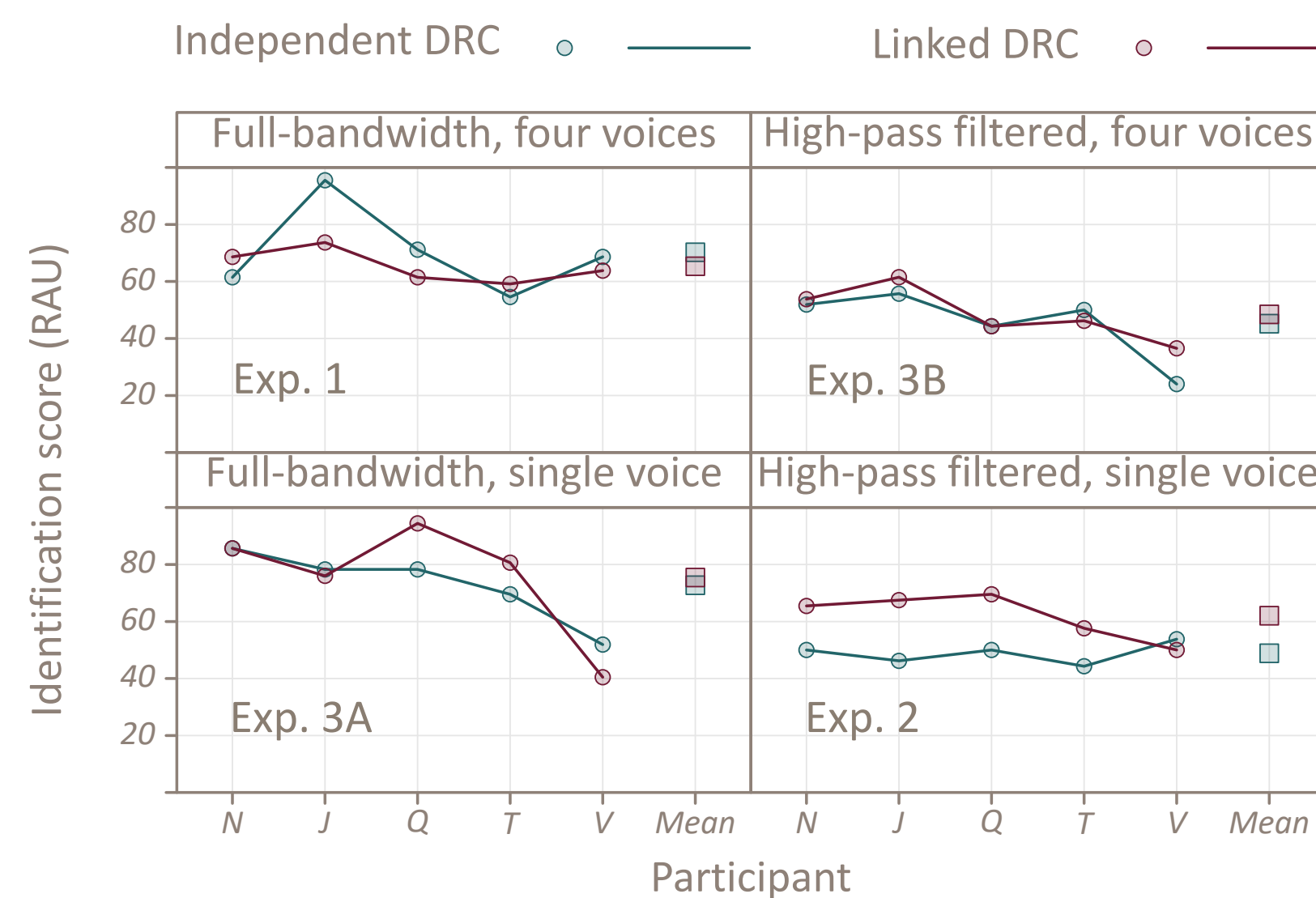
→ [Significant effect](#) of DRC linking [$\chi^2(1)=7.3, p<0.01$]; interaction not significant [$p>0.5$]

Experiment 3: Intermediate cue

- [5 HA users](#) returned from Exp. 1 and 2
- Sequential CRM, full-bandwidth with single voice (Exp. 3A)
- Sequential CRM, high-pass filtered with four different voices (Exp. 3B)

→ Linked-DRC benefit vanishes when multiple segregation cues are present

→ ILD a subordinate cue?



Conclusions

- No effect of single reflection on word identification
- [Significant benefit of DRC linking](#) for high-pass filtered word identification
- Benefit vanishes if voice cue and/or low-frequencies are introduced

→ Did listeners fall back to better-ear glimpsing when more cues were present? (Linked DRC did not change short-term better-ear SNRs but provided less gain than indep. DRC)

→ Are [ILDs irrelevant after all](#)?

→ Is it possible that experienced HA users have learned not to use distorted ILD cues?

Acknowledgment/References

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Arweiler (2011). “Processing of spatial sounds in the impaired auditory system,” Phd thesis, TU Denmark. Bolia et al. (2000). “A speech corpus for multitaler communications research,” J. Acoust. Soc. Am., 107(2), 1065–1066. Hagerman and Olofsson (2004). “A method to measure the effects of noise reduction algorithms using simultaneous speech and noise,” Acta. Acust. Acust. 90, 356–361. Schwartz and Shinn-Cunningham (2013). “Effects of dynamic range compression on spatial selective auditory attention in normal-hearing listeners,” J. Acoust. Soc. Am., 133(4), 2329–2339. Wiggins and Seeber (2013). “Linking dynamic-range compression across the ears can improve speech intelligibility in spatially separated noise,” J. Acoust. Soc. Am., 133(2), 1004–1016.