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INTRODUCTION

- Hypothesis:** Early bilateral stimulation is not required for emergence of spatial hearing acuity in children with cochlear implants (CIs)
- A recent study (Grieco-Calub & Litovsky, 2012), measured spatial acuity in toddlers fitted with unilateral vs. bilateral CIs (BiCIs)
 - Some toddlers with BiCIs obtained Minimum Audible Angle (MAA) thresholds in the range of peers with normal hearing
 - Other toddlers with BiCIs, and **all** toddlers with unilateral CIs (UCIs) were unable to perform the MAA task even at large angular separations
- The current study aims to investigate emergence of spatial acuity in these children as they grow older and gain more bilateral experience

METHODS

Participants

- Twelve of the 39 toddlers in the Grieco-Calub & Litovsky 2012 study returned for follow up testing between the ages of 49 – 85 months
- All twelve children had BiCIs for the duration of the current study
 - Six had UCIs during initial visit as toddlers in the previous study
 - Six had BiCIs as toddlers in the previous study
- Six children (3 from UCI toddler & 3 from BiCI toddler groups) were followed longitudinally with return visits every 12-14 months

Table 1: Participant Information

	Symbol in Graphs	Subject Code	Gender	Etiology	Age at 1 st Implant (months)	Age at 2 nd Implant (months)	1 st CI (internal device & processor)	2 nd CI (internal device & processor)
UCI @ toddler	▲	CICQ	M	Usher Syndrome Type 1	14.0	43.0	Contour Advance; Freedom SP	Contour Advance; Freedom SP
	◆	CICM	M	Connexin 26	12.5	38.0	90K HiRes; PSP	90K HiRes; PSP
	●	CICN	F	Connexin 26	15.5	34.5	Contour Advance; Freedom SP	Contour Advance; Freedom SP
	■	CICL	M	Connexin 26	17.0	32.5	Contour Advance; Freedom SP	Contour Advance; Freedom SP
	▼	CICX	F	Unknown	20.0	27.0	Contour Advance; CP810	Contour Advance; CP810
	◆	CIBV	M	Connexin 26	17.0	23.0	HiRes 90K/HiFocus; Harmony SP	HiRes 90K/HiFocus; Harmony SP
BiCI @ toddler	△	CICA	M	Unknown	28.5	28.5	PULSARci100; OPUS2 SP	PULSARci100; OPUS2 SP
	◇	CICF	F	Bacterial Meningitis	17.5	28.0	Contour Advance; Freedom SP	Contour Advance; Freedom SP
	○	CICB	F	Connexin 26	10.0	24.5	CI24R (CS); Freedom SP	Contour Advance; Freedom SP
	□	CIDC	M	Unknown	19.0	19.0	HiRes 90K/HiFocus; PSP	HiRes 90K/HiFocus; PSP
	▽	CIDL	F	Connexin 26	14.0	19.0	PULSARci100; OPUS2 SP	SONATAti100; OPUS2 SP
	◇	CICK	M	Connexin 26	12.0	14.0	HiRes 90K/HiFocus; PSP	HiRes 90K/HiFocus; PSP

Stimuli

- Recordings of 25 spondees spoken by male talker (e.g., ice cream, bird nest)
- Stimulus level varied randomly over an 8 dB range (60 ± 4 dB SPL)

Procedure

- MAA:** 2-AFC task; Source locations varied for fixed pairs of speakers equi-distant from midline; MAA = smallest angle at which performance $\geq 75\%$ correct
- Sound Localization:** 15-AFC task; Source location varied randomly at each of 15 possible locations from -70° to $+70^\circ$ azimuth and 0° elevation; 150 trials

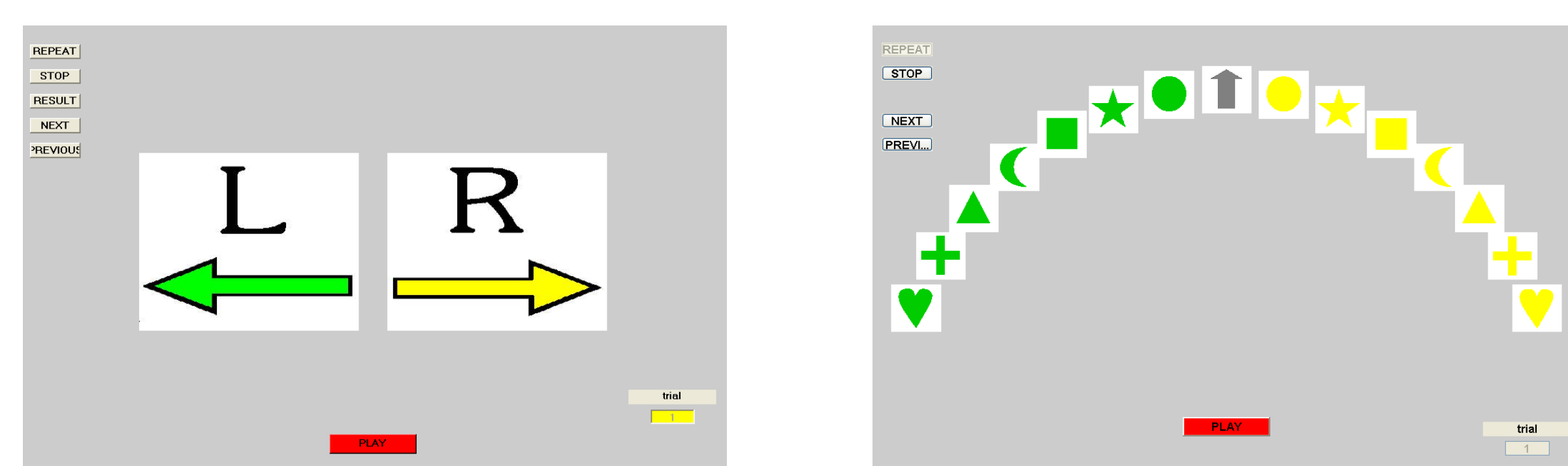
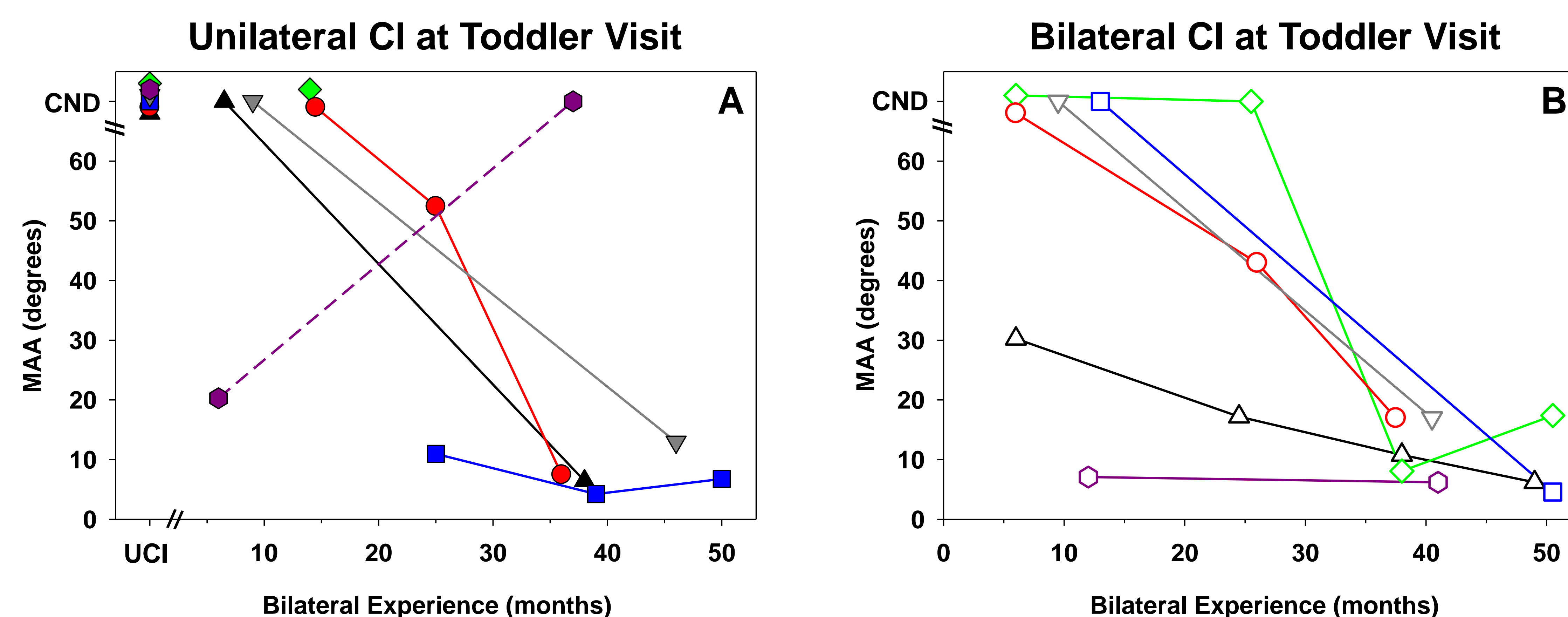


Figure 1: Response screen as viewed by subjects during MAA (left) and sound localization (right) tasks

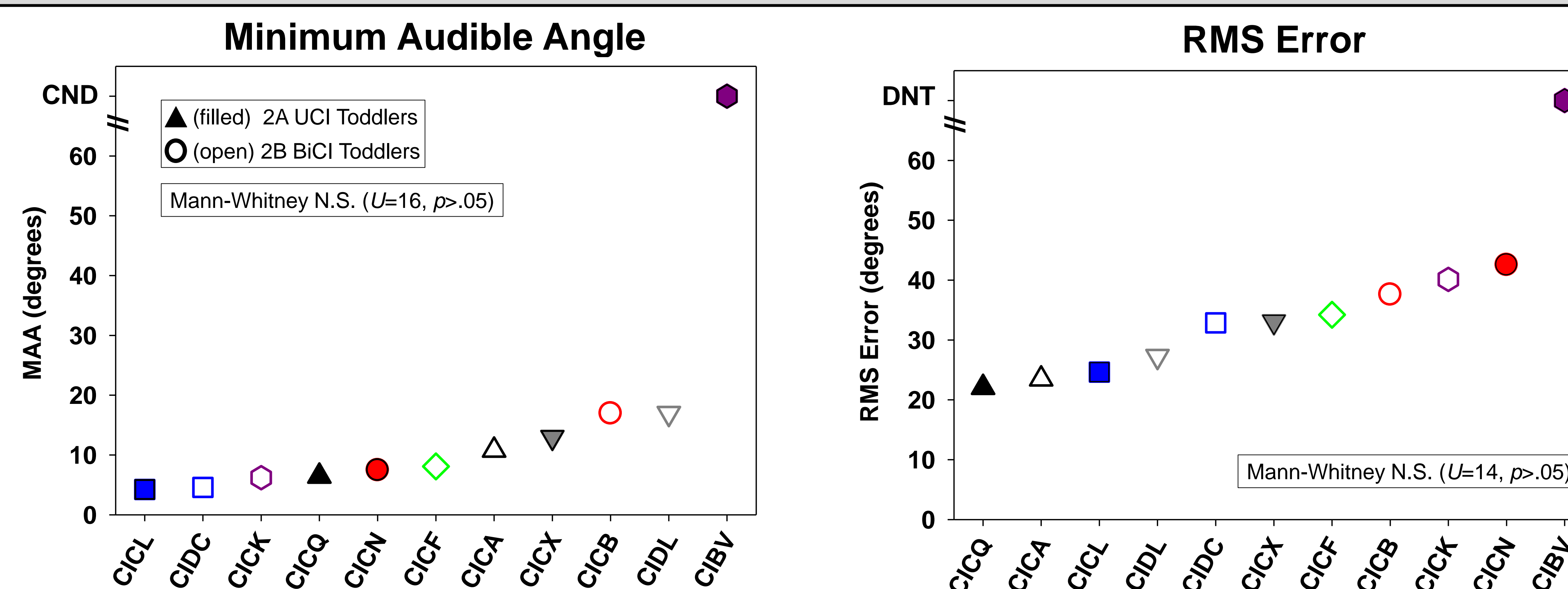
RESULTS

Figure 2: Minimum Audible Angle vs. bilateral experience



- Longitudinal individual MAA data show that thresholds decrease with bilateral experience (one exception), reaching $<20^\circ$ by 24-45 months
- At 40 months of bilateral experience there was no difference in MAA thresholds between children who were able to perform the task as toddlers and children who were unable to do the task (CND) as toddlers

Figure 3: Minimum Audible Angle & Localization RMS Error at first visit with ≥ 36 mo bilateral experience



- With ≥ 36 months of bilateral experience, 10/11 children obtained MAA thresholds between $4-17^\circ$ (left panel)
- Those 10 children were also tested on sound localization and showed RMS errors between $22-42^\circ$
- Localization RMS was not related to whether children were implanted bilaterally (open symbols) or unilaterally (filled symbols) during their initial testing as toddlers

CONCLUSIONS

- Results suggest that there is an emergence of spatial hearing acuity regardless of whether or not children were able to perform the MAA task as toddlers
- Some of the best performers for MAA and for sound localization were children who were unable to perform the MAA task as toddlers (from both the BiCI and UCI groups)
- These findings suggest that early bilateral implantation may not be required for the emergence of spatial hearing acuity, as measured with the MAA task or for sound localization ability

REFERENCE

Grieco-Calub, T.M. and Litovsky, R.Y. (2012). "Spatial Acuity in two-to-three-year-old children with normal acoustic hearing, unilateral cochlear implants and bilateral cochlear implants," *Ear Hear.* 33, 561-572.

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