

Supplemental Material S1. Effects of age at implantation and language achievement with age as a discrete variable (age groups): Information provided by authors for cochlear implant (CI) users and calculated effect sizes (NC = not calculable from information provided).

Authors	Groups	<i>N</i>	Mean age at CI (SD) [range]	Mean age at test (SD) [range]	Mean duration of CI use (SD) [range]	Language domain: Assessment/task ²	Statistical analyses ¹	Primary findings	Effect size (Glass' <i>d</i>)
<i>N</i> age groups									
Artières, Vieu, Mondain, Uziel, & Venail (2009)	Group 1	32	1.7 y [1.1–1.9]	3.9 [2.7–6.4]	2.7 [1.1–4.5]	Receptive vocabulary: PPVT Expressive language (5-levels scale of development)	<i>t</i> tests Logistic regression	Differences between groups were more consistent for groups of later-implanted children (mean age at CI 3.6 vs 4.5); Regression analysis: better receptive vocabulary scores were significantly associated with age at CI. No association with expressive language.	Group 1 vs group 2 PPVT at age 5: .69 Expressive language at age 4: .80
	Group 2	15	2.6 y [2.5–2.9]	8 [5.6–9.1]	5.3 [3.1–6.6]				Group 2 vs group 3 Expressive language at age 5: 1.001
	Group 3	14	3.6 y [3.3–3.7]	6.9 [5.8–10.2]	3.1 [2.5–6.3]				Group 3 vs group 4 PPVT at: age 5: .95 age 6: 1.2 age 8: .83 Expressive language at: age 5: 1.0 age 6: .98 age 8: .81
	Group 4	13	4.5 y [4.3–4.6]	9.9 [7.2–11]	4.5 [2.7–6.2]				—
Colletti, Mandalà, Zoccante, Shannon, & Colletti (2011)	Group 1	19	6.4 mo (2.8) <i>n</i> = 10	—	10-year follow-up	Receptive vocabulary: PPVT	Wilcoxon-Mann-Whitney	Earliest-implanted group outperformed later implanted groups on both tasks.	NC
	Group 2	16	19.3 mo (3.8)	—		Receptive grammar: TROG			
	Group 3	33	30.1 mo	—					

			(5.9) <i>n</i> = 21						
Connor, Craig, Raudenbush, Heavner, & Zwolan (2006)	Group A1	21	21 mo	—	4 years [up to 13 years]	Receptive vocabulary: PPVT (raw scores)	Hierarchical linear modeling (HLM); Regression	Earliest implanted group had greater rates of vocabulary growth than children in other groups for the first 3 years after implantation.	NC
	Group A2	15	36 mo	—					
	Group 2	20	50 mo	—					
	Group 3	44	90 mo	—					
Dettman, Dowell, Choo, Arnott, Abrahams, Davis, ... & Briggs (2016)	Group 1	151	0.70 y (0.15)	PPVT: 5.6 y (0.87) (<i>n</i> = 207) PLS: 5.4 y (1.0) (<i>n</i> = 95) CELF: 8.02 y (2.22) (<i>n</i> = 122)	PPVT: 3.4 y (1.1) PLS: 3.8 y (1.0) CELF: 6.03 y (2.02)	Receptive vocabulary: PPVT Receptive and expressive language: PLS 4 and 5 Receptive and expressive language: CELF	Regression ANOVA	Group 1 outperformed other groups for all language measures (Group 1 had longer CI experience at the time of PPVT and PLS testing).	(PPVT at school entry) vs group 2: .89
	Group 2	61	1.24 y (0.14)						vs group 3: .91
	Group 3	66	1.75 y (0.13)						vs group 4: -1.8
	Group 4	82	2.60 y (0.43)						vs group 5: .03
	Group 5	43	4.45 y (0.69)						—
Holt & Svirsky (2008)	Group 1	6	10.2 mo	From 12 to 96 months	From 6 to 90 months	Receptive language: MBCDI or RDLS Expressive language: MBCDI or RDLS	Regression (on DTA) HLM	Receptive: differences between groups were significant throughout the entire follow-up period. Expressive: no differences between the two earlier-implanted groups (1-2).	NC
	Group 2	32	18.6 mo						
	Group 3	37	29.9 mo						
	Group 4	21	40.8 mo						
Miyamoto, Hay-McCutcheon, Iler Kirk, Houston, & Bergeson-Dana (2008)	Group 1	8	Before 12 mo	—	PLS at 6 mo to 1 y of use (<i>n</i> =13); RDLS at 2-3 y of use	Receptive language: - PLS (standard scores) - RDLS (language quotients); Expressive language: - PLS (standard scores) - RDLS (language quotients)	ANOVA (RDLS)	Differences in language quotients between earlier-implanted and later-implanted groups were not statistically significant.	Group 1 vs group 2: -Receptive RDLS LQ: -.17 Expressive RDLS LQ: .06 Receptive PLS: 1.05
		38	From 12 to 23 mo	—					Group 2 vs group 3:

	Group 2								Receptive RDLS LQ: .43 Expressive RDLS LQ: .42 Receptive PLS: .85
	Group 3	45	From 24 to 36 mo	—					—
May-Mederake (2012)	Group 1	total $N = 28$	> 12 mo	From 33.3 (7.3) to 72.6 (16.3) mo	From 1.77 to 4.45 y depending on the subtest	Receptive language: SETK (6 subtests depending on chronological age); Receptive grammar: TROG ($n = 19$)	Mann-Whitney	Children in group 1 had higher scores ($p = .076?$) than children in group 2 only for the Sentence comprehension subtest ($n = 15$).	NC
	Group 2		12–18 mo						
	Group 3		18–24 mo						
Nicholas & Geers (2017)	Group 1	27	Total sample = 19.23 mo (8.51)	4.5 y	Total sample = 35.54 mo (8.47)	Expressive language measures (spontaneous samples: - NDRW - MLU-w - NDBM	Effect sizes (Cohen’s d) on mean differences in z -scores; Pearson correlations	Effect sizes of mean differences in z -scores between groups were large for ages at CI below 18 months.	Cohen’s d ranged between .31 and 1.02 (Table 4 in the article)
	Group 2	42							
	Group 3	24							
	Group 4	14							
	Group 5	22							
Niparko, Tobey, Thal, Eisenberg, Wang, Quittner, ... & CDaCI Investigative Team (2010)	Group 1	72	15.5 mo (3.2)	51.6 mo	Testing at 3 y of use	Receptive and expressive language: RDLS	Non-parametric regression	Children in group 1 (< 18 mo) had significantly higher rates of growth for both receptive and expressive language than children in other groups.	NC
	Group 2	64	29.4 mo (5.6)	65.7 mo					
	Group 3	52	48.5 mo (7.4)	85 mo					
Percy-Smith, Busch, Sandahl, Nissen, Josvassen, ... & Cayé-Thomassen (2013)	Group 1	28	Total sample = 19.6 mo	Total sample = 46.3 mo	Total sample = 25.9 mo	Receptive vocabulary: PPVT-4 Receptive language: RDLS “Active vocabulary” (Viborgma-teriale)	Fisher’s exact tests Logistic regression Odds ratios (Wald tests)	Children in group 1 (age at CI: 5–11 mo) had higher odds ratios than children in other groups.	NC
	Group 2	19							
	Group 3	36							
Svirsky, Teoh, & Neuburger (2004)	Group 1	12	19.7 mo (1.9)	From 16 to 84 months	—	Expressive language: MBCDI or RDLS	t tests DTA	Children in group 1 had better expressive language skills (for various durations of use).	NC
	Group 2	34	29.8 mo (3.4)		—				
	Group 3	29	40.6 mo		—				

			(2.5)						
Dichotomized age at implantation									
Dunn, Walker, Oleson, Kenworthy, Van Voorst, Tomblin, ... & Gantz (2014)	Group 1 (CI under age 2)	13	1.38 y (0.27)	7.8 y (2.7) [3.0–12.8]	Periodical testing at 7 to 11 years of age	Receptive language: CELF-3 (subtest Concepts and Directions) Expressive language: CELF-3 (subtest Formulated Sentences)	<i>t</i> tests	At 7 years of age, the younger implanted group had higher both receptive and expressive language scores. By 8 to 10 years of age, no difference was found.	Receptive language: at age 7: .72 at age 9: .59 Expressive language: at age 7: .92 at age 10: .63 at age 11: .44
	Group 2 (CI from 2 to 4 y)	25	2.99 y (0.55)	12.2 y (5.04) [3.2–22.4 y]					
Houston & Miyamoto (2010)	Group 1 (CI from 7 to 12 mo)	7	Total sample = 14.8 mo [7.6-22.6]	—	Testing at 2-2.5 and 3-4 years of CI use	Receptive vocabulary: PPVT	<i>t</i> tests	At both intervals, earlier-implanted group had better scores than the later-implanted group (n=14 at interval 1; n=11 at interval 2).	At 2-2.5 y of use: 1.25 At 3-4 y of use: 1.44
	Group 2 (CI from 16 to 23 mo)	8							
Leigh, Dettman, Dowell, & Briggs (2013)	Group 1	35	0.84 mo (0.15)	—	Testing at 1,2,3, and 5 years of use	Receptive language: RITLS Receptive vocabulary: PPVT (at 3 years of use)	Correlations	Receptive language: average growth rate was not different between both groups; Receptive vocabulary at age 3: standard scores were correlated with both age at hearing aids fitting and age at CI.	RITLS mean growth: .32 PPVT at 3 years of use: 1.09
	Group 2	85	1.60 mo (0.25)	—					
Markman, Quittner, Eisenberg, Tobey, Thal, Niparko, & Wang (2011)	Group 1	34	1.15 y (0.17)	—	Testing at 4-5 years of use	Receptive and expressive language: CASL (core composite)	Regression	Children in group 1 had better scores in each of the four language tasks. Maternal sensitivity was a significant predictor of language outcomes in both groups.	NC NC
	Group 2	62	2.88 y (1.03)	—					
Nicholas & Geers (2013)	Group 1	27	9.6 mo (1.3)	54.4 mo (1.5)	44.9 mo	Receptive vocabulary: PPVT Receptive language: PLS Expressive language: PLS	<i>t</i> tests	Mean scores of the earlier implanted group were statistically higher	Receptive vocabulary: .71 Receptive
		42	14.7 mo (2.5)	54.8 mo (1.3)	40.1 mo				

	Group 2							than those of the later implanted group.	language: .79 Expressive language: .60
Rinaldi, Baruffaldi, Burdo, & Caselli (2013)	Group 1	11	total sample = 14.26 mo (4.69)	total sample = 28.78 mo (5.08)	total sample = 14.52 mo (5.08)	Expressive language: MBCDI - words produced - sentences produced - % complex sentences	<i>t</i> -tests on <i>z</i> -scores	No effect of age at CI (below 12 vs 13-26) on vocabulary size and grammatical skills	words: .50 sentences: .23 %complex: .52 (same as in Table 3 in the article)
	Group 2	11							
Tobey, Thal, Niparko, Eisenberg, Quittner, Wang, et al. (2013)	Group 1	98	total sample = 29 mo [6 mo–4 y 11 mo]	From 4.8 to 11.5 y	Testing at 4, 5, and 6 years of use	Receptive and expressive language: CASL (core composite)	Multivariate analyses Fisher's exact test	Trajectories of the core composite standard scores at 4, 5, and 6 years of CI use did not significantly differ as a function of age at CI.	NC
	Group 2	62							NC
Uziel, Sillon, Vieu, Artieres, Piron, Daures, & Mondain (2007)	Group 1	43	total sample = 4.8 y (2.3 y)	From 12 to 24 y	total sample = 11.7 y (1.7 y)	Receptive vocabulary: PPVT	Odds ratio Chi-square ANOVA	An older age at implantation increased the risk of a PPVT score below the 50th percentile by a 2.6 factor.	NC
	Group 2	39							NC
Wie (2010)	Group 1	13	total sample = 11.3 mo (3.9)	7 to 29 mo	total sample = 37 mo (10.4)	Receptive language: MSEL; MCDI Expressive language: MSEL; MCDI	<i>t</i> tests	Children in group 1 had higher language scores than children in group 2 at all times of testing.	NC
	Group 2	7							

¹Note: DTA = Developmental Trajectory Analysis; HLM = Hierarchical Linear Modeling.

²Note: CASL = Comprehensive Assessment of Spoken Language; CELF = Clinical Evaluation of Language Fundamentals; MCDI = Minnesota Child Development Inventory; MSEL = Mullen Scale of Early Learning; MBCDI = MacArthur-Bates Communicative Development Inventories; PPVT = Peabody Picture Vocabulary Test; PLS = Preschool Language Scale; RDLS = Reynell Developmental Language Scales; RITLS = Rossetti Infant-Toddler Language Scales; SETK = Sprachentwicklungstest für Kinder; TROG = Test for Reception of Grammar; MLU-w = Mean length of utterances-words; NDBM = Number of different bound morphemes; NDRW = Number of different root words.