

Supplemental Material S2. Effects of age at implantation and language achievement with age as a continuous variable: Information provided by authors for cochlear implant (CI) users and calculated effect sizes (NC = not calculable from information provided).

Authors	<i>N</i>	Mean age* at CI (<i>SD</i>) [range]	Mean age at test (<i>SD</i>) [range]	Mean duration of use (<i>SD</i>) [range]	Language domain: Assessment/task ¹	Statistical analyses	Primary findings	Effect size (Glass' <i>d</i>)
Black, Hickson, Black, & Khan (2014)	174	44.02 mo (30) [4–180]	—	Retrospective data from outcome measures at 18 to 24 months of CI use	Various tests depending on chronological age (e.g., PPVT, PLS, CELF) (depending on the measure, <i>n</i> = 38 to 89)	Regression	Age at implantation was not significantly associated with language scores. Strongest predictors were family concern and the presence of an inner ear malformation.	NC
Boons, Brokx, Dhooge, Frijns, Peeraer, Vermeulen, et al. (2012)	288 (not all participants were tested at all times on all tests: <i>n</i> = 115 to 140)	26 mo (13) [6–60]	Up to 8 years old	Testing at 1, 2, and 3 years of CI use	Receptive language: RDLS Expressive Language: SELT (Language quotients)	Regression	Age at implantation was a significant predictor of language skills during the first 3 years after implantation.	NC
Boons, De Raeve, Langereis, Peeraer, Wouters, & Van Wieringen (2013)	70	Median: 20 mo [6–60]	Median: 8 y 2 mo [5–13 y]	Median: 6 y 4 mo [1;6–10;6 y]	Expressive vocabulary: EOWPVT Expressive syntax: CELF	Logistic regression	Age at implantation was not a significant predictor for any of the language components. Strongest predictors were the presence of additional disabilities and multilingualism.	NC
Cuda, Murri, Guerzoni, Fabrizi, & Mariani, (2014)	30	11.8 mo (3.2)	24.2 mo (3.2)	Testing at 36 months of age	Expressive vocabulary and grammar: MBCDI	Regression	Age at implantation and sex (girl) were both associated with a higher number of words; sentence complexity was associated with age at implantation, sex, and maternal education level.	NC
Fagan (2015)	9	12.46 mo	At 12	Testing at 4 and 12	Expressive	Correlations	Age at implantation was	1.53 (at 12)

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		[8.9–14.4]	months of CI use: 25.7 mo (2.05)	months of CI use	vocabulary: MBCDI		associated with MBCDI score at 12 months of use.	months of use)
Geers, Moog, Biedenstein, Brenner, Hayes (2009)	153	2; 4 y (0;11) [0;11–5;1]	5;10 y (0;6) [4;11–6;11]	3;6 y (0;11) [1;0–5;4]	Receptive vocabulary: PPVT Expressive vocabulary: EVT or EOWPVT	Regression	IQ was the strongest predictor of vocabulary and language scores, followed by parent education level.	Receptive vocabulary: .47 Expressive vocabulary: .50
Geers, Nicholas, & Moog (2007)	sample 1: 74 sample 2: 126	28.21 mo (11.60)	70.04 mo (7.06) [60–83]	—	Receptive vocabulary: PPVT	Regression	Five variables (age at implantation, gender, parent education, age at hearing aid fitting, and age at test) accounted for 24% of the variance in PPVT scores.	sample 1: .96 sample 2: .54
Geers, Nicholas, & Sedey (2003) Geers (2004)	181	3;5 y (0;10) [1;8–5;4]	8;11 y (0;6) [7;11–9;11]	5; 6 y (0;9) [3;9–7;6]	Receptive language: TACL Expressive language: lexical and grammatical measures converted in a Total Language Score	Regression	Age at implantation was not significantly associated with language achievement.	NC
Geers & Nicholas (2013)	60	22.7 mo (7.7) [12–38]	Testing at 10.5 years old	8.6 y (1) [7–11]	Receptive vocabulary: PPVT Expressive vocabulary: EOWPVT Receptive language: CELF Expressive language: CELF	Regression	Age at implantation and a set of additional variables (related to auditory, personal, and family factors) were associated with language outcomes at 10.5 years old.	PPVT: .67 EOWPVT: .95 CELF (receptive): .80 CELF (expressive): -.85
Hay-McCutcheon, Iler Kirk, Henning, Gao, & Qi (2008)	30	4.48 y (1.61) [1.4–7.7]	Regular testing up to 18 years old	—	Receptive and expressive language: RDLS and CELF	Regression (mixed-effects)	Age at CI was significantly associated with early receptive and expressive language measures (from 2 to 7	NC

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							years of age), but not the later language measures (from 9 years old onwards).	
Hayes, Geers, Treiman, & Moog, (2009)	65	2.69 y (0.90) [1.08–4.75]	5 y (at first test) longitudinal yearly testing	2.39 y (1.29) (at first test) [0–6.42]	Receptive vocabulary: PPVT	Multilevel regression models (growth curve analyses)	Children who received a CI at a younger age showed a faster receptive vocabulary growth rate than children who received an implant later.	NC
Lund (2015) Meta-analysis of 16 studies	34 to 158	16 to 46.5 mo	49 to 109 mo	—	Receptive and expressive vocabulary	Meta-regression	Neither age at implantation, nor duration of use, nor age at the time of testing were associated to the magnitude of weighted effect sizes.	—
Nicholas & Geers (2007; 2008; 2009)	76	23.16 mo (7.75) [12–38]	Testing at 3.5 and 4.5 years old	At 3.5 y: 19.76 mo (7.64) [7–32] At 4.5 y: 55.09 mo (1.15) [52–57]	Receptive and expressive vocabulary and language (various tests: PPVT, EOWPVT, PLS, CELF)	Regression (linear and quadratic)	Age at CI and a set of additional variables (related to auditory, personal, and family factors), were associated with language outcomes.	NC
Schorr, Roth, & Fox (2008)	39	[1;3–8;2 y]	9 y [5;4–14;11]	[1;8–11;8 y]	Various tests according to chronological age (e.g., PPVT, TOLD)	Regression	Age at implantation was associated only with receptive vocabulary scores.	NC
Szagun & Stumper (2012)	25	20.4 mo (11) [6–42]	—	Testing at 12, 18, 24, and 30 months of CI use - Analyses at 30 months of CI use	Expressive vocabulary: word types Expressive grammar: MLUm Expressive vocabulary and grammar: MBCDI	Correlations ANCOVA	At 30 months of use, only maternal education was significantly associated with language measures.	Language sample: -word types: .32 -MLUm: .34 MBCDI: -words: .56 -sentence complexity: .58

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								-inflectional morphology: .84
Szagan & Schramm (2015)	48	24 mo (10) [6–46]	—	Testing at regular intervals from 6 to 36 months of CI use	Language sample: -MLUm -Type and token frequencies of determiners -Type frequencies of lexical words	Regression Correlations	Language measures from 6.5 up to 20 months of CI use were not associated with age at implantation. At 24 and 30 months of use, age at CI added 9% and 10% of unique variance of MLU (parental expansions accounted for 48% and 43% of the unique variance of MLU).	MLU at 24 months of use: .46 MLU at 30 months of use: .50
Tomblin, Barker, Spencer, Zhang, & Gantz (2005)	29	21 mo (7) [10–40]	5 to 78 mo	—	Expressive language: MCDI PLS (converted into an Expressive Language Quotient (ELQ))	Hierarchical linear model	Both at 12 and 24 months of CI use, age at implantation was significantly associated with ELQs.	PLS ELQ at 24 months of use: -1.8 MCDI ELQ at 12 months of use: .85 at 24 months of use: -1.35
Willstedt-Svensson, Löfqvist, Almqvist, & Sahlén (2004)	15				Receptive grammar: TROG Expressive grammar: Lund Test of Grammar	Regression	Age at CI was associated with both receptive and expressive grammar scores; with working memory added as a predictor, age at CI did not account for a significant proportion of variance.	Receptive grammar: 1.75 Expressive grammar: 1.5

*mo: months; y: years

¹Note: MCDI = Minnesota Child Development Inventory; TOLD = Test of Language Development; MLUm = Mean length of utterances (morphemes); SELT = Schlichting Expressive Language Test; CELF = Clinical Evaluation of Language Fundamentals; MBCDI = MacArthur-Bates Communicative Development Inventories; PPVT = Peabody Picture Vocabulary Test; PLS = Preschool Language Scale; RDLS = Reynell

Developmental Language Scales; TACL = Test of Auditory Comprehension of Language; TROG = Test for Reception of Grammar; EVT = Expressive Vocabulary Test; EOWPVT = Expressive One-Word Picture Vocabulary Test.