

SUPPLEMENTAL DIGITAL CONTENT 1

TABLE A1. Demographic information of all subjects who participated in this study

Subject Number	Sex	Ear Tested	AAI (yrs)	AAT (yrs)	Electrodes Tested	PPD (μ s)	Internal Device and Electrode Array	MRI Result	
								CN	Cochlea
CND1	F	L	1.2	2.5	1, 5, 10	50, 50, 50	24RE (CA)	*	IP-2
CND2	M	R	2.1	4.1	1, 5, 8	50, 50, 50	24RE (CA)	*	Normal
CND3	M	R	6.6	8.5	3, 6, 10	50, 50, 50	24RE (CA)	#	Normal
CND4	F	L	1.3	3.3	3, 12, 21	50, 50, 50	24RE (CA)	*	Normal
CND5	F	L	3.4	5.4	3, 10, 18	50, 50, 50	24RE (CA)	*	Normal
CND6	M	L	1.9	2.4	1, 7, 14	50, 50, 50	24RE (CA)	*	Normal
CND7	M	L	4.7	10.8	15, 19, 22	37, 37, 37	24RE (ST)	Small	IP-2
CND8	F	L	1.7	3.8	6, 12, 18	75, 75, 88	24RE (CA)	Small	Normal
CND9	F	L	2.1	8.2	3, 11, 16	75, 50, 50	24RE (CA)	Absent	Normal
CND10	F	L	2.1	5.5	2, 4, 10	75, 100, 100	24RE (CA)	#	Normal
CND11	M	L	7.8	10.0	3, 12, 21	75, 75, 75	24RE (CA)	Small	Normal
CND12	M	L	2.1	4.5	3, 12, 17	25, 25, 25	24RE (CA)	#	Normal
CND13	M	L	9.4	9.7	3, 12, 18	50, 50, 50	24RE (CA)	Small	Normal
CND14	F	L	5.1	7.2	3, 9, 15	88, 88, 88	CI512	Small	Normal
CND15	M	L	4.1	7.9	1, 6, 9	50, 50, 50	24RE (CA)	Absent	Normal
CND16	M	R	3.8	4.1	1, 6, 9	75, 75, 75	24RE (CA)	Small	Normal
CND17	M	R	2.5	4.8	6, 15, 21	50, 50, 50	24RE (CA)	#	Normal
CND18	F	R	4.0	5.0	3, 12, 21	37, 37, 37	24RE (CA)	*	Normal
CND19	F	R	2.9	6.5	1, 5, 8	50, 50, 50	24RE (CA)	*	Normal
CND20	F	R	2.1	4.2	1, 4, 7	50, 50, 50	24RE (CA)	Small	Normal
CND21	F	L	1.9	2.5	3, 12, 21	50, 50, 50	24RE (CA)	#	Narrow
CND22	M	L	2.1	4.7	3, 12, 21	37, 37, 50	24RE (CA)	*	Normal
CND23L	F	L	10.8	15.0	3, 6, 9	37, 50, 62	24RE (CA)	Small	IP-2
CND23R	F	R	3.8	15.1	3, 12, 21	50, 50, 50	24RE (CA)	Small	IP-2
NSCN1	F	R	2.4	3.0	3, 12, 21	25, 25, 25	CI422		
NSCN2	M	L	3.5	4.4	4, 12, 21	25, 25, 25	24RE (CA)		
NSCN3	F	R	0.9	2.1	3, 12, 21	25, 25, 25	CI422		
NSCN4	M	R	2.3	6.8	3, 12, 21	25, 25, 25	24RE (CA)		

NSCN5	M	L	1.6	3.2	3, 12, 21	25, 25, 25	24RE (CA)
NSCN6	M	R	3.6	6.3	3, 12, 21	25, 25, 25	24RE (CA)
NSCN7	F	R	3.5	6.5	3, 12, 21	25, 25, 25	CI512
NSCN8	M	L	8.5	9.4	3, 12, 21	25, 25, 25	24RE (CA)
NSCN9	M	L	4.3	8.4	3, 12, 21	25, 25, 25	CI512
NSCN10	F	R	3.5	6.5	3, 15, 21	25, 25, 25	CI512
NSCN11	F	R	3.0	11.5	3, 12, 21	25, 25, 25	24RE (CA)
NSCN12	M	L	6.5	7.7	3, 12, 21	25, 25, 25	24RE (CA)
NSCN13	F	R	2.1	4.3	3, 12, 21	25, 25, 25	24RE (CA)
NSCN14	F	R	1.7	2.5	3, 12, 21	25, 25, 25	24RE (CA)
NSCN15	F	L	6.3	8.5	3, 12, 19	25, 25, 25	24RE (CA)
NSCN16	M	R	1.0	2.9	3, 12, 19	25, 25, 25	24RE (CA)
NSCN17	M	R	3.3	5.6	3, 12, 19	25, 25, 25	24RE (CA)
NSCN18	F	L	5.7	8.1	3, 12, 21	25, 25, 25	24RE (CA)
NSCN19	M	L	2.4	3.4	3, 12, 19	25, 25, 25	24RE (CA)
NSCN20	M	L	1.7	4.0	3, 12, 19	25, 25, 25	24RE (CA)
NSCN21	M	R	2.7	3.0	3, 12, 19	25, 25, 25	24RE (CA)
NSCN22L	M	L	1.3	2.6	3, 12, 19	25, 25, 25	CI512
NSCN22R	M	R	1.3	2.6	3, 12, 19	25, 25, 25	24RE (CA)
NSCN23	M	R	1.8	4.0	3, 12, 19	25, 25, 25	24RE (CA)
NSCN24	M	R	6.1	9.8	3, 12, 21	25, 25, 25	24RE (CA)
NSCN25L	M	L	1.0	12.9	3, 12, 21	25, 25, 25	24RE (CA)
NSCN25R	M	R	1.0	12.9	4, 12, 21	25, 25, 25	24RE (CA)
NSCN26L	M	L	2.4	3.4	3, 12, 21	25, 25, 25	24RE (CA)
NSCN26R	M	L	1.7	4.0	4, 12, 21	25, 25, 25	24RE (CA)
NSCN27	M	R	3.2	6.2	4, 12, 21	25, 25, 25	CI512
NSCN28	M	L	1.3	2.6	3, 12, 22	25, 25, 25	CI532
NSCN29	F	L	0.8	11.9	3, 12, 20	25, 25, 25	24RE (CA)
A1	M	L	58.9	61.8	3, 12, 20	25, 25, 25	CI512
A2	M	L	60.7	69.0	3, 12, 18	25, 25, 25	CI512
A3	M	R	43.3	52.7	3, 12, 21	25, 25, 25	24RE (CA)
A4L	F	L	56.0	67.5	3, 12, 21	25, 25, 25	24RE (CA)
A4R	F	R	54.4	67.6	3, 12, 21	25, 25, 25	24RE (CA)
A5L	M	L	72.8	80.8	7, 12, 21	25, 25, 25	CI512
A5R	M	R	77.5	80.7	3, 9, 21	25, 25, 25	24RE (CA)
A6	M	R	52.5	61.5	3, 12, 21	25, 25, 25	CI512

A7L	F	L	54.6	55.4	4, 12, 21	25, 25, 25	CI532
A7R	F	R	44.7	54.7	3, 12, 21	25, 25, 25	24RE (CA)
A8	M	R	60.3	62.8	4, 12, 21	25, 25, 25	CI522
A9	M	R	25.6	36.8	3, 12, 21	25, 25, 25	24RE (CA)
A10	F	L	33.0	36.7	3, 12, 21	25, 25, 25	CI512
A11	F	R	48.5	59.6	3, 12, 21	25, 25, 25	24RE (CA)
A12	F	R	64.9	65.6	3, 12, 21	25, 25, 25	CI532
A13L	M	L	70.2	70.4	3, 12, 21	25, 25, 25	CI532
A13R	M	R	68.7	70.4	3, 12, 21	25, 25, 25	CI532
A14	F	L	72.5	76.6	3, 12, 21	25, 25, 25	CI522
A15	F	R	15.2	28.7	3, 12, 21	25, 25, 25	24RE
A16	M	R	73.0	74.2	3, 9, 12	25, 25, 25	CI522
A17	M	L	74.0	79.0	3, 12, 21	25, 25, 25	CI422
A18	M	R	59.0	59.5	3, 12, 21	25, 25, 25	CI532
A19	F	R	75.7	79.8	3, 12, 21	25, 25, 25	24RE
A20	M	L	68.5	70.2	11, 18, 20	25, 25, 25	CI532

*Two Small nerves in the auditory canal

#Single nerve in the internal auditory canal (i.e. nerve diameter <3 mm).

AAI, age at implantation; AAT, age at testing; PPD, pulse phase duration; CN, cochlear nerve; 24RE (CA), Freedom Contour Advance electrode array; 24RE (ST), Freedom Straight electrode array; IP-2, incomplete partition 2.

SUPPLEMENTAL DIGITAL CONTENT 2

Classification Methods

We compared three different algorithms for classifying the presence of cochlear nerve deficiency (CND) for pediatric cochlear implant (CI) users from recordings of electrically-evoked compound action potentials (eCAPs). Each participant was classified as having CND and given a label of 0 or as having a normal-sized cochlear nerve (NSCN) and given a label of 1. The three classifying algorithms that were compared were linear regression with elastic net regularization, support vector machine regression with a linear kernel, and logistic regression with elastic net regularization. The classification boundary was chosen to be 0.5 for all three models. In other words, if the predicted score for an individual patient was greater than 0.5, the individual would be classified as having a NSCN (i.e., label = 1). Otherwise, the individual was classified as having CND (i.e., label = 0).

Five-fold cross validation

The data from all participants were first randomly split into 5 folds of equal size, each fold having 1/5 of the children with CND and 1/5 of the children with a NSCN. In each run, 4 folds were used as the training data set to find the model parameters, and the remaining fold was used to test the model. A total of 5 training and testing runs were completed in which each run used a different fold as the testing fold. The model performance was reported as the average over the 5 runs.

Evaluation Metrics

Accuracy, precision, recall and F-measure score were used to evaluate the performance of the different algorithms and are defined below. For all of these metrics,

the possible values are between 0 and 1, where larger values indicate better classification performance.

Accuracy: the fraction of all correctly classified participants over all participants.

Precision: the fraction of correctly classified children with CND over all the participants that were classified (either correctly or incorrectly) as having CND.

Recall: the fraction of correctly classified children with CND over the total number of children with CND.

F-measure score: The harmonic mean of precision and recall. Mathematically, this is written as $F1 = 2 \times \frac{recall \times precision}{recall + precision}$.

Results

The performance of each machine learning algorithm in classifying children with CND and children with NSCNs are provided in Table B1 below.

TABLE B1. Performance metrics [mean (SD)] for three classification algorithms.

Performance Metric	Linear	SVM	Logistic
Accuracy	0.93 (0.09)	0.91 (0.11)	0.95 (0.04)
Precision	1.00 (0.00)	1.00 (0.00)	0.97 (0.07)
Recall	0.84 (0.20)	0.77 (0.28)	0.92 (0.10)
F-measure	0.90 (0.12)	0.84 (0.22)	0.94 (0.05)

SVM: support vector machine; F-measure: Harmonic mean of precision and recall