NATURALISTIC MUSIC EEG DATASET—HINDI (NMED-H) 2.0: NEW RELEASE AND CROSS-DATASET COMPATIBILITY

Blair Kaneshiro[1], Duc T. Nguyen[1,2], Jacek P. Dmochowski[1,2], Anthony M. Norcia[1], Jonathan Berger[1]

[1]Stanford University, USA [2]City College of New York, USA

blairbo@ccrma.stanford.edu

EXTENDED ABSTRACT

Recent neuroscience research in Music Information Retrieval has been facilitated by publicly available electroencephalography (EEG) datasets such as the OpenMIIR dataset [7] and the Naturalistic Music EEG Dataset—Tempo (NMED-T) [5, 6]. Here we present a new release of the Naturalistic Music EEG Dataset—Hindi (NMED-H) [3], an open dataset containing EEG responses and behavioral ratings from 48 adult participants who heard intact and temporally scrambled versions of full-length, real-world vocal works ('Bollywood' pop songs). The dataset contains a total of nearly 29 hours of auditory EEG responses, including over 7 hours of responses to intact music. To date, NMED-H data have been used to study neural tracking of time-varying audio features [2] and to assess neural correlation during music listening [4]. In the first major update since its initial release in 2016, NMED-H now contains raw, clean, and spatially filtered EEG records, as well as behavioral ratings and participant-stimulus assignments. Moreover, clean EEG records from NMED-H are now broadly compatible with clean EEG from NMED-T, meaning that data can potentially be aggregated across datasets and analyzed together. NMED-H data are de-identified and are published through the Stanford Digital Repository[1] in Matlab (`.mat`) format under a CC-BY license.

The set of 16 stimuli were four Hindi pop songs in intact, measure-shuffled, reversed, and phase-scrambled conditions. Each of the 48 participants was assigned four stimuli such that every song and every stimulus condition was represented once. Dense-array (128-channel plus reference) EEG was recorded using the Electrical Geodesics, Inc. platform while the participant heard each stimulus twice in its entirety (around 4.5 minutes per stimulus). At the completion of each trial, the participant rated the Pleasantness, Musicality, Order, and level of Interest of the preceding stimulus. Twelve participants were assigned to each stimulus, resulting in $N = 24$ trials collected per stimulus. Complete details on participant demographics, stimulus creation, study design, data acquisition and cleaning, and spatial filtering are provided in Kaneshiro et al. [4].

Published raw EEG records refer to individual continuous (un-epoched) recordings which have undergone only filtering and downsampling; these data are provided for researchers who wish to apply their own preprocessing pipelines. A total of 97 raw electrode-by-continuous-time ($129 \times CT$) files are contained in four zipped archives, with a total zipped/unzipped size of 8.4 GB. A single example file (92 MB) is made available for individual download.

Clean EEG records are ready-to-use data frames which have undergone trial epoching, artifact rejection, rereferencing, imputation of missing values, and across-trials aggregation. A total of 32 files are presented in four zipped archives (one archive per stimulus condition), with a total zipped/unzipped size of 12.4 GB. Each file contains an electrode-by-time-by-trial ($125 \times T \times 12$) matrix of responses for a particular stimulus and listen. A single example file (387 MB) is made available for individual download.

Spatially filtered EEG records are clean EEG records which have been pooled across listens on a per-stimulus basis and then filtered using Reliable Components Analysis (RCA) [1] on a per-condition basis. This form

[1]https://purl.stanford.edu/sd922db3535

of the data has been used for computing neural correlation [4]; it may also be useful for other analyses, as the spatial dimension of each response matrix is reduced from >100 electrodes to 5 mutually uncorrelated components, most with improved SNR. Data are provided in a single zipped archive (zipped/unzipped size of 496 MB) containing four files, each of which contains component-space EEG and spatial filter parameters for a single stimulus condition. Responses to individual stimuli are stored in time-by-component-by-trial ($T \times 5 \times 24$) matrices as elements of a cell array. A single example file (124 MB) may also be downloaded.

Finally, behavioral ratings of the stimuli and a participant-stimulus assignment file are presented in small (<1 KB) files.

The clean data records of NMED-H and NMED-T share the same sampling rate, reduced (125-channel) electrode montage, electrode reference, and data shape. Therefore, while the datasets reflect slightly different preprocessing pipelines [4, 6], their data are broadly compatible. NMED-T contains over 15 hours of EEG responses to intact music (20 participants each hearing 10 stimuli between 4.5–5 minutes in length) [6]. In NMED-H, responses to intact stimuli constitute 7.2 hours of music listening total (24 trials for each of four stimuli around 4.5 minutes in length). Cross-dataset aggregation thus produces over 22 hours of ready-to-use EEG responses across 14 full-length musical works. We note that participant numbering was assigned independently for each dataset, so researchers should not treat corresponding participant identifiers as same individuals. There may also be participants whose data appear in both NMED-H and NMED-T, but it is not possible to map specific individuals across datasets. Cross-dataset aggregation is possible after preprocessing the raw recordings as well; researchers are advised to consult the documentation of each dataset as the published continuous recordings differ slightly with regard to filtering and sampling rate [3, 6].

Our aims in releasing the NMED-H dataset have been to advance music neuroscience research through access to data—enabling more researchers to work with the data and expanding potential scientific insights that may be drawn from the data—while also promoting reproducibility and comparison of techniques and results across studies and research groups. In our own work we have used NMED-H in conjunction with freely available analysis code [2, 4]. In its current release we have provided multiple forms of the data in order to accompany recently reported results [4], and to facilitate its usage with NMED-T [5]. As future work, we continue to analyze both of the published datasets; we also analyze additional data collected under other studies, which will eventually be released as NMED datasets as well.

ACKNOWLEDGMENTS

The creation of this dataset was supported by the Wallenberg Network Initiative: Culture, Brain, Learning and the Patrick Suppes Gift Fund.

REFERENCES

[1] J. P. Dmochowski, A. S. Greaves, and A. M. Norcia. Maximally reliable spatial filtering of steady state visual evoked potentials. *NeuroImage*, 109:63–72, April 2015.

[2] N. Gang, B. Kaneshiro, J. Berger, and J. P. Dmochowski. Decoding neurally relevant musical features using Canonical Correlation Analysis. In *Proceedings of the 18th International Society for Music Information Retrieval Conference*, 2017.

[3] B. Kaneshiro, D. T. Nguyen, J. P. Dmochowski, A. M. Norcia, and J. Berger. Naturalistic Music EEG Dataset—Hindi (NMED-H). In *Stanford Digital Repository*, 2016. http://purl.stanford.edu/sd922db3535.

[4] B. Kaneshiro, D. T. Nguyen, A. M. Norcia, J. P. Dmochowski, and J. Berger. Natural music evokes correlated EEG responses reflecting temporal structure and beat. *bioRxiv*, 705517, 2019.

[5] S. Losorelli, D. T. Nguyen, J. P. Dmochowski, and B. Kaneshiro. Naturalistic Music EEG Dataset—Tempo (NMED-T). In *Stanford Digital Repository*, 2017. https://purl.stanford.edu/jn859kj8079.

[6] S. Losorelli, D. T. Nguyen, J. P. Dmochowski, and B. Kaneshiro. NMED-T: A tempo-focused dataset of cortical and behavioral responses to naturalistic music. In *Proceedings of the 18th International Society for Music Information Retrieval Conference*, 2017.

[7] S. Stober, A. Sternin, A. M. Owen, and J. A. Grahn. Towards music imagery information retrieval: Introducing the OpenMIIR dataset of EEG recordings from music perception and imagination. In *Proceedings of the 16th International Society for Music Information Retrieval Conference*, 2015.