The researchers are interested in evaluating if EEGs (electro-encephalograms, or readings of brainwaves) can predict audibility of speech. The specific type of EEG responses used are called envelope following responses (EFRs). EFRs are recorded with scalp electrodes when speech is presented in an individual’s ear and they represent neural activity that follows the periodicity in speech.

研究人员有兴趣评估EEG（脑电图或脑波读数）是否可以预测语音的可听性。使用的特定类型的EEG响应称为包络响应（EFR）。当在个体的耳朵中呈现语音时，EFR用头皮电极记录，并且它们表示遵循语音周期性的神经活动。

Experiment Design: In this experiment, we use 8 speech sounds (aka carriers) to elicit EFRs - /u/F1, /u/F2, /a/F1, /a/F2, /i/F1, /i/F2, sh and s. F1 and F2 refer to the first and second vowel formants, respectively. We use a range of stimuli because we are interested in evaluating audibility at low, mid and high frequencies (perceived as pitch). The F1 carriers are low frequency dominant, the F2 carriers are mid frequency dominant and the fricatives (sh and s) are high frequency dominant. EFRs are quantified by their amplitude (response amplitude) and phase (degrees). To evaluate if there is an EFR, we use two methods: (i) we compare its amplitude with noise amplitude using an F-test and (ii) we compare the inter-trial phase consistency using a Rayleigh test. P-values of < 0.05 are considered “detected” EFRs. We expect an EFR to be detected if the stimulus is audible.

实验设计：在这个实验中，我们使用8个语音（也称为载波）来引出EFR - / u / F1，/ u / F2，/ a / F1，/ a / F2，/ i / F1，/ i / F2，嘘和s。 F1和F2分别指第一和第二元音共振峰。我们使用一系列刺激，因为我们有兴趣评估低频，中频和高频（可感知音高）的可听度。 F1载波是低频主导，F2载波是中频主导，摩擦音（sh和s）是高频主导。 EFR通过其幅度（响应幅度）和相位（度）来量化。为了评估是否存在EFR，我们使用两种方法：（i）我们使用F检验比较其振幅与噪声振幅，以及（ii）我们使用瑞利检验比较试验间相位一致性。 P值<0.05被认为是“检测到的”EFR。如果刺激是可听见的，我们期望检测到EFR。但是，因为EFRs的幅度减小了刺激

However, because EFRs reduce in amplitude as stimulus levels get quieter, we may not be able to detect EFRs at very quiet levels. Loudness, or sound pressure level (SPL), is measured in units of decibels (dBs). In each participant, the 8 stimuli were presented at 4 levels (20, 35, 50 and 65 dB SPL) ranging from inaudible/very quiet levels (20 dB SPL) to loud levels (65 dB SPL). Audibility for each stimulus and each level was quantified by sensation level expressed as dB SL. Positive SLs mean that the stimuli were audible and negative SLs mean that the stimuli were inaudible. You can interpret SL roughly as (SPL − threshold of Carrier), i.e., comparing SPL vs. the participant’s known audible threshold for that sound. At any given stimulus level (e.g., 20 dB SPL), some of the 8 stimuli may be audible and some may not be.

然而，由于随着刺激水平变得更安静，EFR的幅度减小，我们可能无法在非常安静的水平上检测到EFR。响度或声压级（SPL）以分贝（dBs）为单位测量。在每个参与者中，8个刺激呈现4个级别（20,35,50和65 dB SPL），范围从听不见/非常安静的水平（20 dB SPL）到大声水平（65 dB SPL）。每个刺激和每个水平的可听度通过表示为dB SL的感觉水平来量化。正SL表示刺激是可听见的，负SL表示刺激是听不见的。您可以粗略地将SL解释为（SPL - 载波的阈值），即比较SPL与参与者已知的该声音的可听阈值。在任何给定的刺激水平（例如，20dB SPL）下，8种刺激中的一些可能是听觉的而一些可能不是。

SL: 感觉水平基于每个参与者已知的声音的可听阈值

(a) How accurately can the audibility of each speech stimulus be predicted using EFRs? We will mainly consider detectability, which is a binary outcome. Does accuracy differ between carriers or frequency groups?

(b) Is there a difference in performance between the F-test and the Rayleigh in predicting audibility?

(c) What is the minimum SL needed in order for the EFR to detect a response? How does the minimum SL vary by carrier or frequency group?

How does the minimum SL vary by carrier or frequency group

(d) What are the limitations of your methods? Pay special attention to the independence assumption. Any remedies?