Dai & Shinn-Cunningham, 2018:

* **Lagging stream: 200ms after Leading stream**
* In each block, one stream from 0, other from a lateral position
* Focus on either Leading or Lagging (based on visual cue)
* **Streams are isochronous**
* Onset of EACH trial differed
* Hearing threshold of <20dB
* Additional 0.02$ bonus with each correct answer
* Sequences differed in repetition rate, so that EEG responses elicited by onsets of the notes were resolvable in time
* **Leading Stream:**
  + **Sound event duration: 624ms**
  + **ISI: 664ms**
  + **Total: 1288ms (tlo1)**
* **Lagging Stream:**
  + **Delay: 200ms**
  + **Sound event duration: 728ms**
  + **ISI: 758ms**
  + **Total: 1486ms (tlo2)**
* **On and off gating? 🡪 onsets, duration and offsets 🡪 10ms, dur, 100ms**
* **Starting SPL: 70dB**
* **48 trials each block 🡪 10 blocks in total 🡪 480 trials**
* **band-pass filtered from 1.8 Hz to 50 Hz**🡪 using a **6,000-point finite-impulse response band-pass filter (least-squares brick-wall filter)**
* **calculated ERPs from responses on channel Cz** (channel 32 in the 10/20 system). Epochs were extracted from each raw trace, **then band-pass filtered from 2 Hz to 25 Hz** using the eegfiltfft.m function in EEGLab toolbox (43). Any trial epoch with a **peak magnitude greater than 90 μV was rejected to remove artifacts** (roughly 3 to 6% of trials were rejected)
* a **bootstrap** procedure to estimate evoked EEG responses
* **took the average of 100 randomly chosen trial epochs, with replacement, chosen from the distribution of artifact-free responses for a given subject and condition**. **The final estimate was the mean of 200 repeats of this procedure**
* **N1 magnitude was estimated as the local minimum 90 ms to 220 ms after a note onset**, and the **P1 magnitude was estimated as the local maximum from 30 to 120ms** after the onset🡪 difference in these magnitudes was used to quantify the early neural response for each condition and subject
* For each trial in the auditory selective attention experiment, epochs were defined from **3 s before to 6 s** after the auditory stimulus onset was extracted. For the ITD threshold experiment, **each trial epoch was defined as 0.5 s before to 1 s after the auditory stimulus onset**. For each subject, we calculated the ERP magnitudes separately for large ITD, a small ITD, and 0 ITD trials
* **Attention modulated index calculated**🡪 normalized difference in neural response to a stream when it is attended to when it is ignored
  + A higher AMI 🡪 P1-N1 magnitude in response to the note is larger when the listener is attending to that stream
* After the first note, **Distractor notes overlapped with other streams and tended to produce smaller ERPs**. For these reasons, we separately analyzed responses to the first note and the later notes of the Distractor

Dai & Shinn-Cunningham, 2016:

* NHTs at frequencies between 250 Hz and 8000 Hz (thresholds of at most 20 dB HL) for both ears
* Stream A and Stream B
* Equal amplitude🡪 70dB SPL (root-mean-squared)
* **Repetition Rates chosen carefully🡪 ensure they were not harmonically related to each other or to 60Hz**
* Any interference from neural responses to competing streams and any ongoing line noise was random across bins🡪 tended to cancel out
* **Stream A🡪 10 notes**
* **Stream B🡪 8 notes**
* Program **recorder the last button push within the response period** as the registered answer within that time
* Band-pass filter 2-25Hz
* Focused on channel Cz (32)
* **Epochs: -0.2s until tlo end**
* Maximum absolute peak voltage for each epoch
  + **Histogram of peak values across trials, rejected trials in the top 15% of each subject’s distribution**
  + **Bootstrap**🡪 avg ERPs for when Stream A was the target, and when Stream B was the target separately🡪 200-draw bootstrap with replacement (100 trials per draw)
* **N1 magnitude 100-220ms, P1 30-100ms after onset**
  + **Difference computed🡪 avg peak-to-peak P1-N1 magnitude**
  + Estimated the P1-N1 magnitude in response to each note onset in Stream A and B when Stream A was the target, and vice versa
  + **First notes in each stream omitted**
  + M attended expected to be larger than M ignored
* **ERP magnitudes vary significantly across subject🡪 the factors cause shifts in measured ERPs that are constant on a logarithmic scale**
  + **AMI** calculated 🡪 computing the difference of the log of the magnitudes of M attended and ignored
  + For each subject
  + As the avg across note onsets (from 2nd not to final note)
  + **1/N-1 Sum N, pi=2 log(M attended/M ignored)**
    - **N number of notes of s (stream)🡪 sA: N=10; sB: N=8**
* Stats:
  + **Multi-way ANOVA**🡪 mixed effects models
  + Subject-related factors were treated as random effects🡪 were not assumed to comply with **homoscedasticity**
  + Akaike information criterion🡪 to compare models with and without reach random effect term
  + Data checked for normality using Kolmogorov Smirnov test
  + Looked for correlations between variables
  + Significance tested with pearson correlation coefficient
  + P values using a t-tailed student’s t test
* Exp 1:
  + Stimuli:
    - 11 subjects
    - **Stream A: 10 tones, 200ms duration, ISI= 668ms, tlo1=868ms**
    - **Stream B: 8 tones, 300ms duration, ISI=849ms, tol2= 1149ms**
    - All notes time-windowed with cos-squared onset and offset ramps to reduce spectral splatter🡪 10ms duration
    - **1 block, 40 trials**
    - **1st block training**
    - **7 further blocks for test🡪 280 trials in total**

Schönwiesner:

* Same voice
* 2 streams 1 and 2
* Rates: 0.8 and 0.95Hz
* Based on Dai and Shinn-Cunningham 2018
* 200 trials motor-only
* 10 min per spatial axis🡪 480 trials each
* ISI 1: 0.5
* ISI 2: 0.3
* Dur of sounds: 0.75
* Tlo1= 0.95
* Tlo2= 1.05

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Objectives: **to find decodable neural correlates of the direction of attentional focus along azimuth, elevation, and distance from EEG recordings** (WP1.2). **Unclear whether binaural cues are necessary for successful attention decoding**. The two streams are presented at different rates (0.8 and 0.95 Hz), which **allows separating the EEG responses by time-locked averaging** (Fig. 3A). This is a continuous response adaptation of the paradigm used by Dai and Shinn-Cunningham (2018). Listeners indicate on a keypad each number heard at the attended location. We acquire 480 trials in 10 min per spatial axis, and another 200 trials in a “motor-only” condition in which listeners press buttons but do not receive auditory stimuli.

**Set up so far:**

* n\_blocks = 10
* n\_trials1 = 56
* n\_trials2= 48
* isi = (664, 758)
* # choose speakers:
* speakers = (-17.5, 17.5) # directions for each streams
* s2\_delay = 2000
* sample\_freq = 48828
* numbers = [1, 2, 3, 4, 5, 6, 8, 9]

mean\_n\_samples = int(numpy.mean(n\_samples\_ms))

* tlo1 = int(isi[0] + (mean\_n\_samples)) # isi + (mean sample size of sound event / sample freq)
* tlo2 = int(isi[1] + (mean\_n\_samples))
* t\_end = n\_trials1 \* tlo1
* n\_trials2 = int(numpy.ceil((t\_end - s2\_delay) / tlo2))
* speaker selection randomized (where target stream is played from)🡪 50% chance
* should wav files all be equalized? So that they all last the same
* elevation: speakers at idx 12 + 5? 🡪 channels: 20 + 26🡪 how to select

Script:

Für die nächste Stunde wirst du an einer neurobiologischen Studie teilnehmen, bei der Elektroenzephalographie verwendet wird, um die Aufmerksam während eines auditiven Verhaltensexperiments zu untersuchen. Unser Ziel ist es, herauszufinden, wie gut du dich konzentrieren kannst und wie gut du eintreffende Geräusche aus verschiedenen Richtungen wahrnehmen kannst, nicht nur auf der horizontalen Ebene, sondern auch auf der vertikalen Ebene.

In der ersten Hälfte des Experiments werden die Elektroden sorgfältig auf deinem Kopf platziert, um die Veränderungen in der Hirnaktivität während des folgenden Experiments aufzuzeichnen. Dies wird etwa 30 Minuten dauern.

Nun zum Versuchsdesign:

Du wirst auf einem Stuhl in einem schalldichten Raum sitzen, ohne Ablenkungen. Du wirst die einzige Person im Raum für die nächsten 20 Minuten sein. In deiner Hand hältst du ein Tastenfeld mit den Zahlen 1-9. Die Zahl sieben ist ausgeschlossen und darf nicht gedrückt werden (das steht auch auf dem Tastenfeld).

Als Vorbereitung auf das eigentliche Experiment wirst du jetzt gebeten, zufällig auf das Tastenfeld zu drücken, für etwas mehr als zwei Minuten. Dir wird gesagt, wann du aufhören sollst. Danach können wir mit weiteren Erklärungen fortfahren.

Was als Nächstes passieren wird, ist, dass du zwei Stimmen hören wirst, die aus zwei verschiedenen Lautsprechern kommen (eine von links und eine von rechts). Der knifflige Teil ist, dass beide Lautsprecher tatsächlich die gleiche Stimme abspielen werden. Der Unterschied besteht darin, wie schnell jede Stimme abgespielt wird (sie werden also nicht vollständig überlappen). Die Stimmen aus beiden Quellen werden die Zahlen von 1 bis 9 (außer 7) nacheinander sagen, insgesamt etwa 1 Minute lang. Dein Ziel ist es, dich auf die Zielstimme zu konzentrieren und die entsprechenden Zahlen auf dem Tastenfeld zu drücken. Die Zielstimme wird immer von dem Lautsprecher abgespielt, der etwas früher startet als der andere. Ob sie vom linken oder rechten Lautsprecher kommt, wird zufällig festgelegt. Die verzögerte Stimme ist dazu da, dich abzulenken. Versuche so viele richtige Antworten wie möglich zu geben. Du wirst benachrichtigt, wenn der Block beendet ist. Dies wird 10 Mal wiederholt, daher insgesamt 10 Minuten.

Derselbe Ablauf wird auch für die vertikale Achse folgen. Wenn du Fragen hast, stehe ich gerne zur Verfügung.

Englisch:

For the next hour, you'll be part of a neurobiological study involving electroencephalography to explore how well you can focus and distinguish incoming sounds from different directions, not just horizontally but also vertically.

In the first half of the experiment, electrodes will be carefully placed on your head to record changes in brain activity during the upcoming experiment. This will take about 30 minutes.

Now, let's talk about the experiment setup:

You'll be seated in a chair inside a soundproof room with no distractions. You'll be the only person in the room for the next 20 minutes. In your hand, you'll hold a keypad with numbers 1-9, but remember, number seven should not be pressed (it will be labelled on the keypad).

As a warm-up for the actual experiment, you'll be asked to randomly press buttons on the keypad for a little over two minutes. We'll let you know when to stop, and then we can move on with further instructions.

Here's what happens next: You'll hear two voices coming from two different speakers—one from the left and one from the right.The trick is, both speakers will play the same voice, but they'll differ in the speed at which each voice is played, so they won't completely overlap. These voices will say numbers from 1 to 9 (excluding 7) one after the other for approximately one minute in total. Your goal is to focus on the target voice and press the corresponding numbers you hear on the keypad. The target voice will come from the speaker that starts playing a bit earlier than the other one. Whether it's played from the left or right speaker will be random. The delayed voice is there to distract you. Try to press as many correct answers as possible. We'll notify you when each block ends, and this will be repeated 10 times, totalling 10 minutes.

The same procedure will be applied for the vertical axis as well. If you have any questions, please feel free to ask.