2pPP18

Characteristics of visually-induced auditory spatial adaptation

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Objective

In our everyday life, we combine spatial information from the auditory (head-centered reference frame) and visual (eye-centered reference frame) systems.

Research in neurophysiology and psychophysics experiments supports that auditory and visual spatial information may be processed in a hybrid reference frame (combination of both).

This study investigated whether visually-guided recalibration of auditory space in human occurs in a head-centered, eye-centered or a hybrid reference frame.

Experiment setting

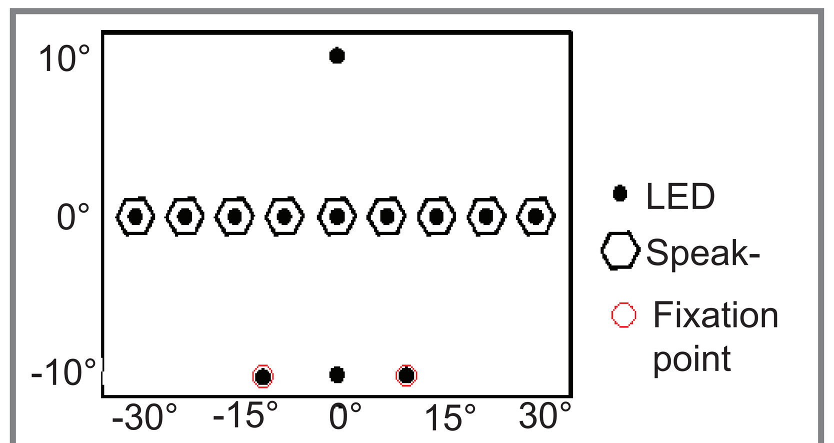


Figure 1 Experimental setting

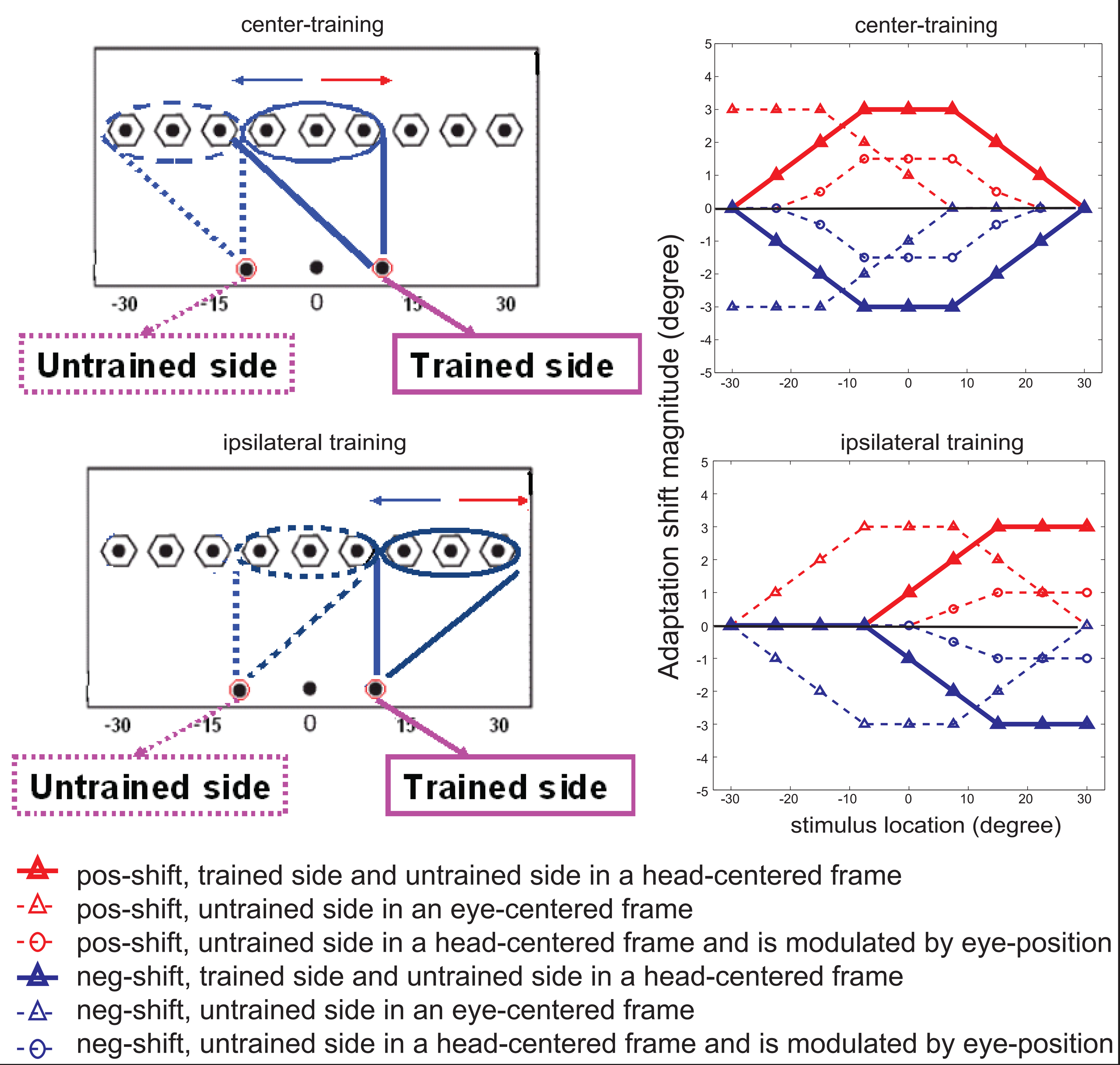
►Nine auditory speakers
-at eye-level
-from -30° to 30°, every 7.5°
-100ms broadband noise was used

►29 LEDs
-at the same level as speakers
-from -35° to 35°, every 2.5°

►Fixation points are two LEDs
-at -11° and 11° (left and right fixation points)
-10° lower than the other LEDs.

Response method: eye movement is tracked by the eye tracker (subjects' head was fixed by chin rest).

Hypothesis



Procedure

Two training conditions: only center or peripheral (at the same side as the fixation LED) three speakers were used in AV training trials (CENTER v.s. IPSILATERAL).

Three shift conditions:
-no-shift: the LED and the speaker are at the same location.
-positive-shift: the LED is 5° right to the speaker.
-negative-shift: the LED is 5° left to the speaker.

►In each of the two group of experiments with different training positions (center v.s. peripheral), seven normal hearing subjects joined.

►Each session contained: 120 trials per AV training locations intermingled with 40 A-only trials per speaker.

►In the A-only trials, half of them started with fixation point (fp) at the same fp in AV trials (TRAINED SIDE), and half of them started with fp at another fp (UNTRAINED SIDE).

Results

1. Baseline (no shift)

►Only in center training condition: a bias in lateral A-only targets, especially in the same side as the fp in AV trials.

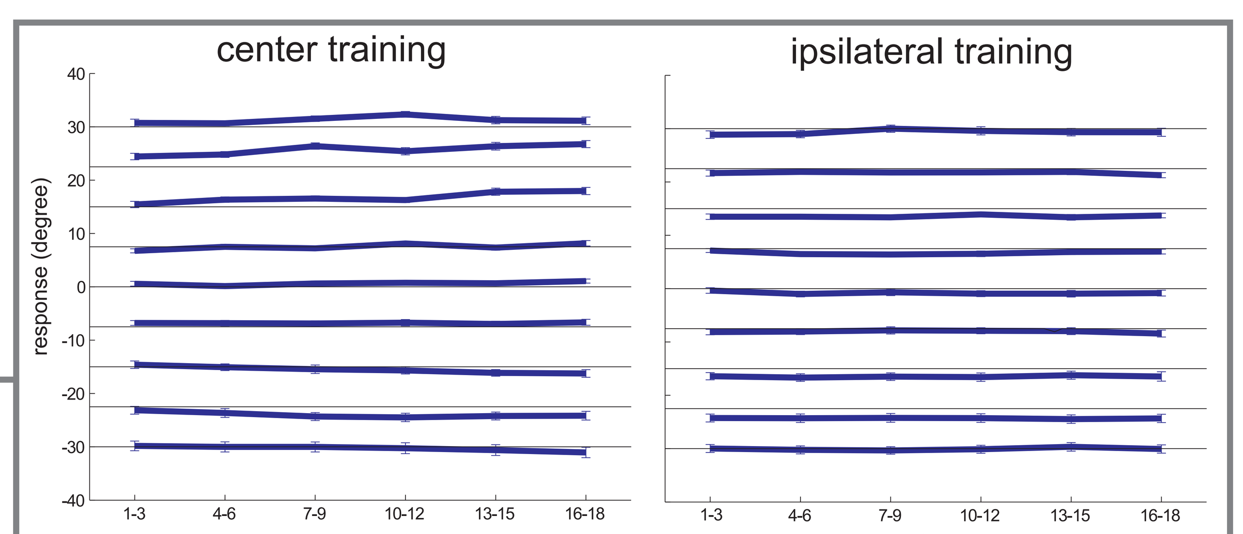
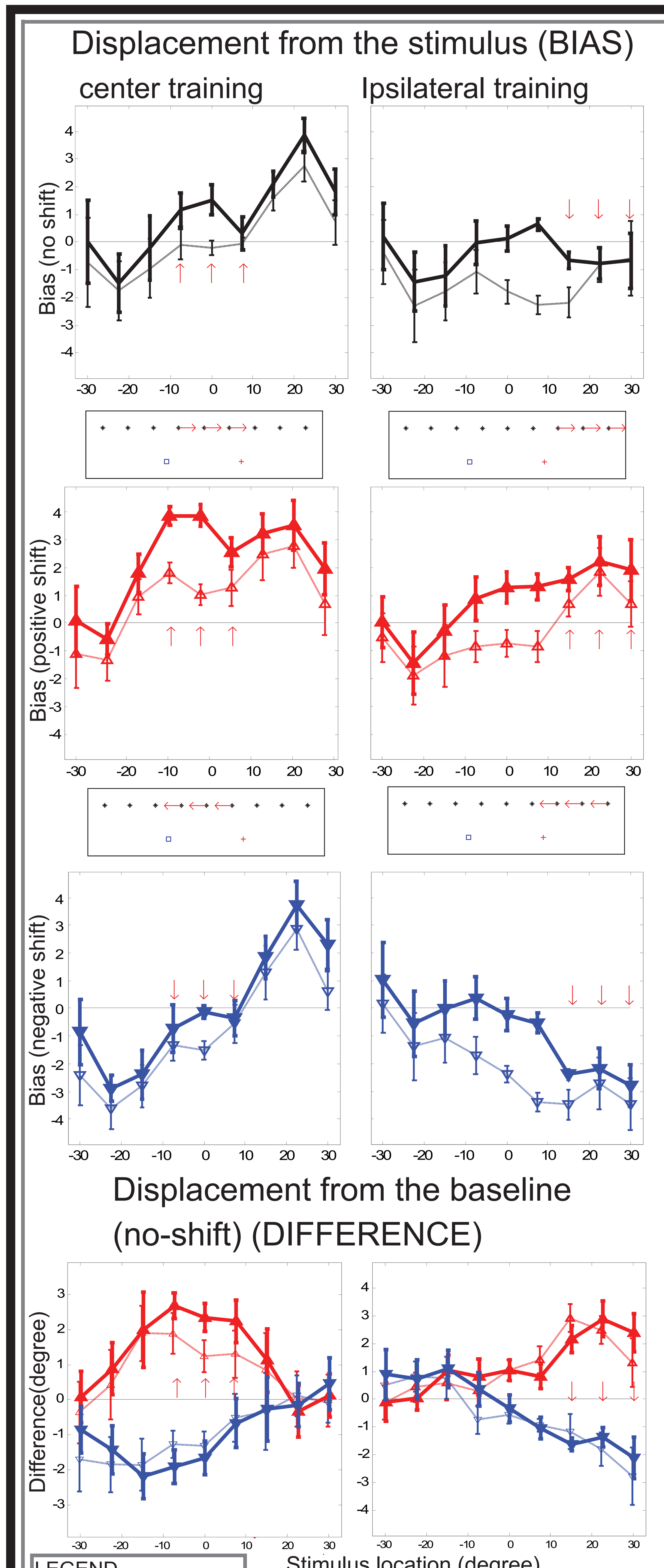


Figure 2 Responses (for each speaker) in no-shift condition (baseline) as a function of trial number in A-only trials across all A-only trials



LEGEND
- AV Discrepancy Training Locations
- Speaker Used on A-only Trials
- Speaker Used on A-only and AV Trials, and Direction of Displacement of LED on AV trials
- Fixation Point of AV and A-only Trials
- Fixation Point of A-only Trials

Figure 3 Bias and Difference as a function of stimuli

- No shift, TRAINED side
- No shift, UNTRAINED side
- Positive shift, TRAINED side
- Positive shift, UNTRAINED side
- Negative shift, TRAINED side
- Negative shift, UNTRAINED side

Results

2. Bias (from the stimulus locations)

►Baseline (no-shift):
-data in the center and ipsilateral training is similar, except at the right-most locations, where the center training data has a large positive bias (discussed in Results Session 1).

►Positive and Negative shift:
-the adaptation shifts were induced at trained locations and in the expected direction (details in Results Session 3).

►Eye fixation position modulation based on attracting nearby target localizations:
-the trained data is always above the untrained data (statistically significantly different).
-the difference between the trained and untrained data is largest at the center three locations (due to attraction from the fixation points in opposite direction)

3. Difference (from the baseline)

The AV 5° discrepancy training induces the adaptation shifts at:

►the trained locations in the TRAINED side. The adaptation shifts
-are approximately constant 2°-3° (except in center negative shift condition)

►Untrained locations in TRAINED side. The adaptation shifts:
-become smaller when the distance from trained locations increases
-disappear for the targets approximately 10° away from the trained locations (except in the center negative-shift condition, where the adaptation shifts in the trained locations are not similar to each other)

►UNTRAINED side. The adaptation shifts are either:
-smaller (center positive-shift condition), or
-shifted in their spatial layout (around 5° in the direction of the fp)

These results mostly support a head-centered reference frame with the possible contribution from the eye position.

4. Correlation analysis for difference

Correlation index is calculated as:

$$C.I.(i)=\frac{\sum[trained(-7.5° \ to \ 30°)*untrained(-7.5°+i \ to \ 30°+i)]}{\sqrt{\sum[trained(-7.5° \ to \ 30°)]^2*\sum[untrained(-7.5°+i \ to \ 30°+i)]^2}}$$

►The correlation index is highest at 0°-shift in a head-centered frame.

►Considering the error bars, -7.5°-shift in a head-centered frame can't be ruled out.

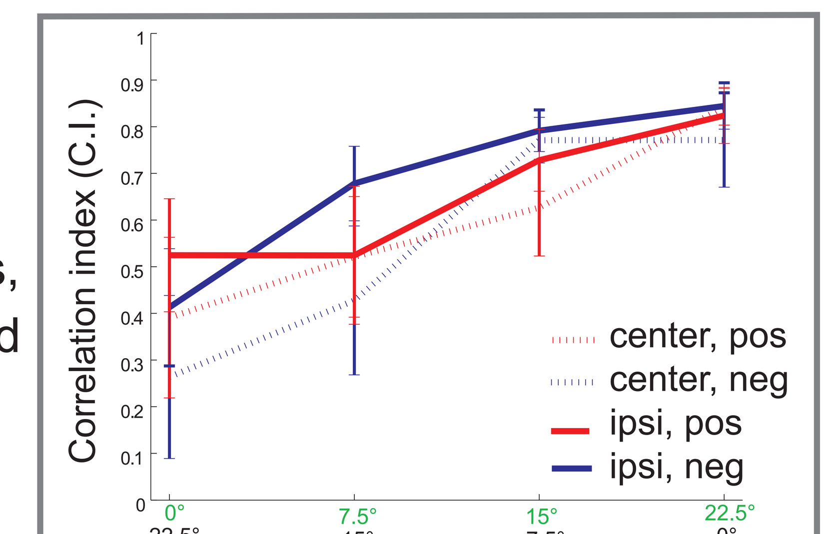


Figure 4 Correlation index across subject. x-axis is:
---toward a head-centered frame from an eye-centered frame.
---toward an eye-centered frame from a head-centered frame (i).

Summary

►Spatially displaced AV stimuli induce the adaptation shifts in auditory localization in the same direction as the displacement. These induced adaptation shifts:
-have size of 40-60% of the AV displacement in the AV training locations.
-decrease (equal or smaller) in size outside the AV training locations.
-can be reduced in size and/or shifted by moving eyes, and they are more consistent with a head-centered than an eye-centered reference frame.

►Eye fixation point modulates sound localization by attracting nearby auditory targets and inducing a bias independent of AV displacement.

►An unexpected form of adaptation also induced when aligned AV stimuli are in center:
-a lateral bias due to over-estimating.

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