The influence of (eye) movements on pitch perception seems to be explained by spatial representations : a psychophysical approach.

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Laboratoire Vision Action Cognition - Université Paris Cité – Paris, France.

Introduction

It is known that action can either bias visual perception (Witt & Proffitt, 2005), or enhance it, owing to the spatial attention allocated to the goal of this action (Carrasco, 2011).

In the field of auditory perception, Hostetter et al. (2019) have investigated the influence of action on pitch perception. In their study, the participants' verbal estimation of tone frequency was overestimated (underestimated) when they were walking upstairs (downstairs).

However, their results could be explained by the mere activation of spatial representations (Connell et al., 2013) or by other verbal biases (semantic pitch-space associations, Dolscheid et al., 2013).

➔ **Given these limitations, we used a psychophysical method to measure the perceived frequency of pure tones when participants made saccades (a simpler and more reproducible movement than walking upstairs or downstairs) or when they fixated a point on a screen.**

Methods

Participants

13 participants were enrolled, 3 were excluded because of failure to perform the task (M_{age} = 19.10; SD_{age} = 2.08 years; 7 females).

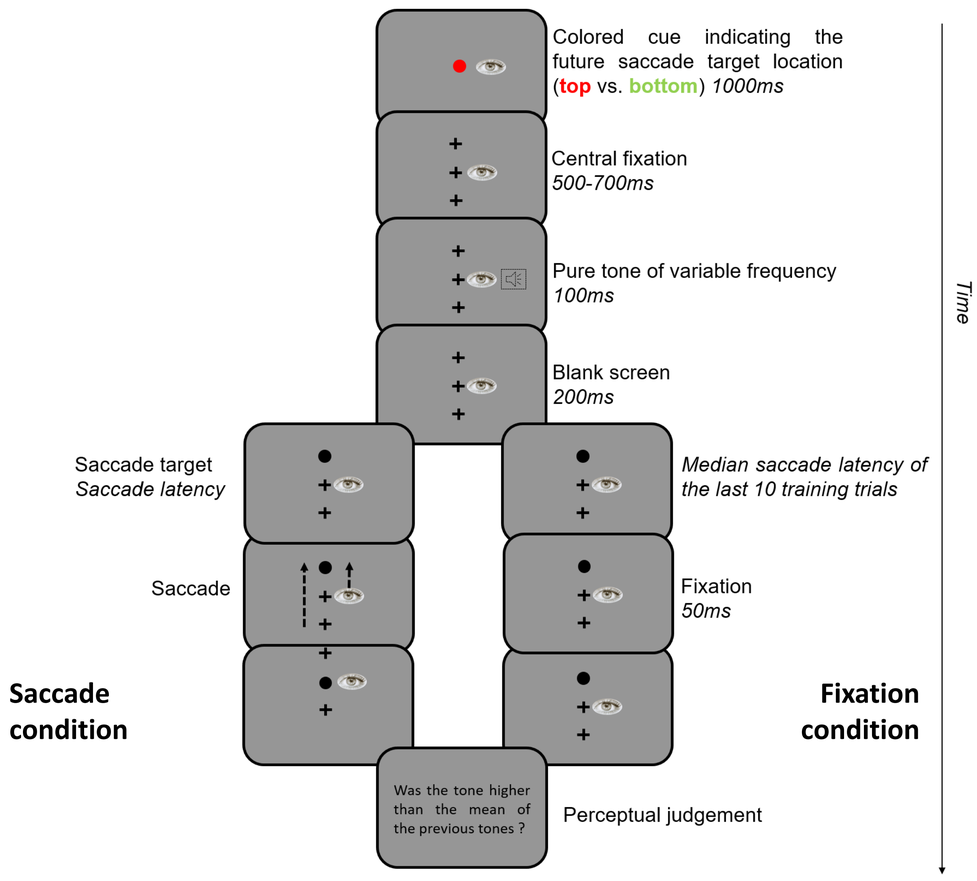
Procedure

1. **Task difficulty adjustment;** 64 QUEST+ trials (Watson, 2017; Paire et al., 2022) were performed to individually adjust the frequency of the tones used in the main experiment.

2. **Training;** 32 trials of the Saccade condition (see below) with feedbacks on tone judgments and saccade latencies.

3. **Fixation (182 trials) & Saccade conditions (182 trials);** Method of Single Stimuli. The order of conditions was counterbalanced across participants. Upward and downward trials were interleaved in each condition.

Trial structure : Pitch comparison to the implicit mean (Single Stimuli).



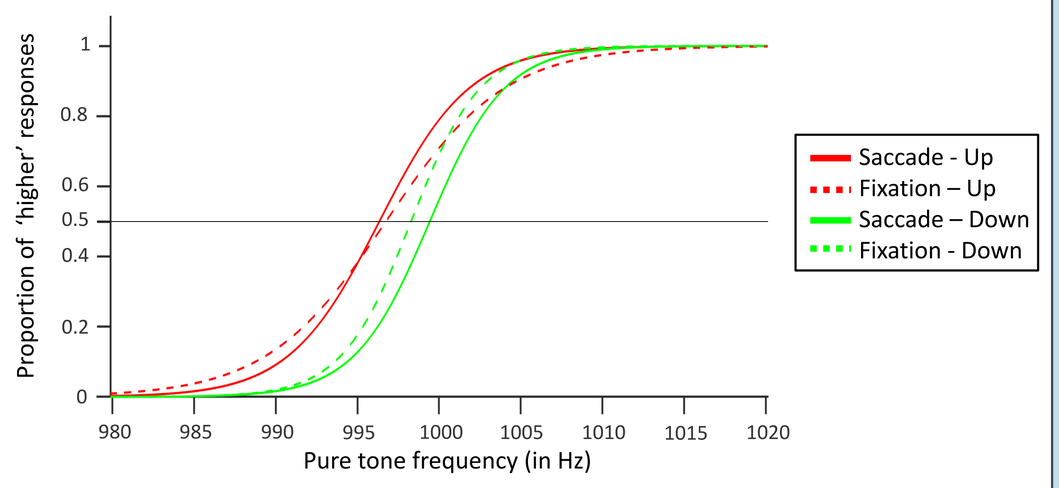
Hypotheses

1. **If spatial representations or semantic pitch-space associations are sufficient to bias pitch perception** → PSEs should be lower when the visual stimulus is displayed at the top of the screen than at the bottom, in both the Saccade and Fixation conditions.

2. **If movement improves pitch perception** → PSEs should be closer to the objective reference frequency (1000 Hz) and JNDs should be lower in the Saccade condition than in the Fixation condition.

Results

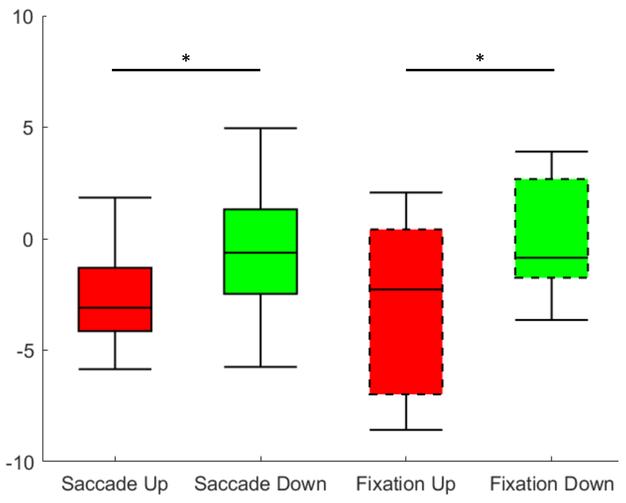
Example of individual data



Psychometric functions for each condition for <u>one representative participant.</u>

As for this participant, overall, observers had lower PSEs in the "upward" conditions (M = 996.99, SD = 3.44 Hz) than in the "downward" conditions (M = 999.64, SD = 2.80 Hz), i.e., participants judged the tones to be higher than their implicit reference more often when the visual stimulus appeared in the upper visual field than in the lower visual field.

PSE Analyses

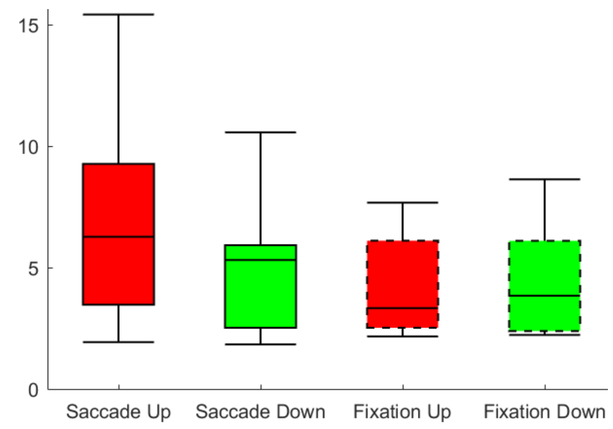


PSEs were significantly lower when the disk appeared at the top of the screen than at the bottom, $F(1,9)$ = 8.08, p = .02, η_p^2= .47.

The other statistical comparisons did not reach significance :

- 'Saccade' vs. 'Fixation', $F(1,9)$ = .15, p = .71.
- 'Stimulus Location' x 'Movement', $F(1,9)$ = .14, p = .72.

JND Analyses



None of the effects tested reached significance :

- 'Up' vs. 'Down', $F(1,9)$ = .83, p = .39.
- 'Saccade' vs. 'Fixation', $F(1,9)$ = 2.44, p = .15.
- 'Stimulus Location' x 'Movement', $F(1,9)$ = 4.05, p = .08.

Analysis of saccade latencies :

There was no significant difference in saccade latencies between the 'Saccade Up' ($M_{Latency}$ = 226.2, $SD_{Latency}$ = 100.4ms) and the 'Saccade Down' experimental conditions ($M_{Latency}$ = 238.1, $SD_{Latency}$ = 102.2ms), $F(1,9)$ = 2.37, p = .16.

Conclusion

These preliminary results **suggest that spatial representations or semantic pitch-space associations are sufficient to bias pitch perception, while movement per se is not necessary.**

➔ These findings qualify the conclusion of Hostetter et al. (2019).

In addition, we can not conclude that saccades **improve pitch perception**.

➔ However, more participants are needed to reach the expected power of .8.

References

Carrasco, M. (2011). Visual attention : The past 25 years. *Vision Research*, 51(13), 1484-1525.
Connell, L., Cai, Z. G., & Holler, J. (2013). Do you see what I'm singing? Visuospatial movement biases pitch perception. *Brain and Cognition*, 81(1), 124-130.
Dolscheid, S., Shayan, S., Majid, A., & Casasanto, D. (2013). The Thickness of Musical Pitch : Psychophysical Evidence for Linguistic Relativity. *Psychological Science*, 24(5), 613-621.
Hostetter, A. B., Dandar, C. M., Shimko, G., & Grogan, C. (2019). Reaching for the high note : Judgments of auditory pitch are affected by kinesthetic position. *Cognitive Processing,* 20(4), 495-506.
Manning, F., & Schutz, M. (2013). « Moving to the beat » improves timing perception. *Psychonomic Bulletin & Review*, 20, 1133-1139.
Paire, A., Hillairet de Boisferon, A., & Paeye, C. (2022). Empirical validation of QUEST+ in PSE and JND estimations in visual discrimination tasks. *Behavior Research Methods*.
Watson, A. B. (2017). QUEST+ : A general multidimensional Bayesian adaptive psychometric method. *Journal of Vision*, *17*(3), 10.
Witt, J. K., & Proffitt, D. R. (2005). See the Ball, Hit the Ball : Apparent Ball Size Is Correlated With Batting Average. *Psychological Science*, 16(12), 937-938.

Université Paris Cité

Laboratoire Vision Action Cognition

Contact: adrien.paire@u-paris.fr ; celine.paeye@u-paris.fr

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