# Influence of Auditory and Visual Distraction on Spatial Localization

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## Introduction

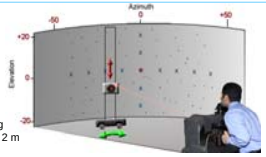
Localization of transient spatial targets requires encoding, consolidation, and memory storage of spatial information. It is commonly held that spatial ("where") and non-spatial ("what") sensory inputs are processed and stored separately [1]. Presumably, disruption of processing along the way, such as by distraction, is parsed similarly. For example, spatial distracters may disrupt spatial localization, while non-spatial distracters generally do not [2,3,4]. The sensory modality as well as the timing of the distracter with respect to a spatial target might further influence spatial performance.

The purpose of this experiment is to determine whether 1) the effect of spatial distracters is modality-specific; 2) spatial localization depends upon timing of distraction presentation: during the encoding of a target location, its consolidation, or later during the memory period.

## Methods

**HUMAN SUBJECTS**

- N=10 (5 M, 5 F; age 19-26 years).
- Normal hearing (0.25-8 kHz) and vision.




**EXPERIMENTAL APPARATUS**

- **Test chamber:** Dark, echo-attenuated room.
- **Head orientation:** Head fixed by a bite bar; subject facing the center of a cylindrical screen of black speaker cloth at 2 m distance.
- **Target Positioning:** Two-axis robotic arm with a range of ±50° horizontal x ±25° vertical.
- **Target Presentation:**
  - Randomly-distributed target locations across the 2-D range.
  - Multi-sampled (x4) target locations at 10° intervals along the primary meridians.

**STIMULUS AND DISTRACTER CHARACTERISTICS**

- **Auditory target:** Gaussian white noise (0.1-20 kHz), 75 SPL (RMS), five 150 ms (1 s total) bursts, with 10 ms rise-fall time.
- **Visual target:** Red LED back-projected on to screen; five 150 ms (1 s total) flashes.
- **Distracters:**
  - *Spatial:* series of three 300 ms (1 s total) pure tones (880 Hz) OR green LEDs, randomly presented from left, right, or center.
  - *Non-Spatial:* series of three 300 ms (1 s total) pure tones (220-880 Hz), varying in pitch.

**EXPERIMENTAL PARADIGM**

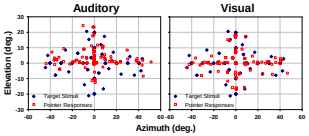
Subjects first pointed to and fixated a central green LED (go-cue). After a 1-2 s delay, an auditory or visual target was presented. Distracter presentation occurred either simultaneously with (encoding period), immediately following (consolidation), or 1 s after (memory) the primary target. Subjects responded to the distracter, while keeping eyes and laser pointer straight ahead. (In the baseline condition, no distraction was presented.) At the go-cue offset (6 s after target offset), subjects then looked and pointed to the remembered primary target and recorded their response with a key press.

**TASK AND RESPONSE MEASURES**

- **Distraction** response
  1 key press = last distracter was perceived from the left (if spatial) OR lower in pitch (if non-spatial) relative to the previous one.
  2 key presses = last distracter was perceived from the right (if spatial) OR higher in pitch (if non-spatial) relative to the previous one.
- **Target localization** response
  - A 2-axis cylindrical joystick was used to point a laser LED at the perceived target location on the screen.
  - Response endpoint was registered with a key press.
- Eye movements were monitored using EOG to assess fixation.

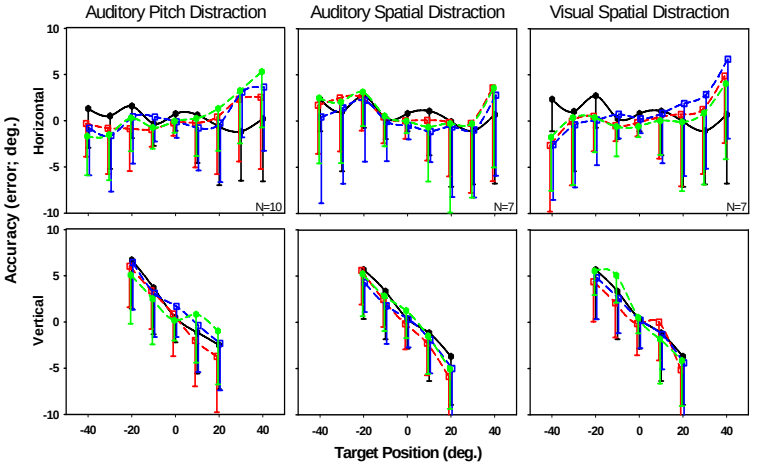
**DATA ANALYSIS**

- Data were sorted by stimulus type (auditory or visual), distraction modality (auditory or visual) and type (spatial or non-spatial), distraction timing, and spatial plane (horizontal vs. vertical).
- Localization *accuracy*: the mean error between the response and target position binned at 10° intervals.
- All measures were averaged across subjects for each target.
- *Spatial gain* (SG) was obtained from regressions of response vs. target position.



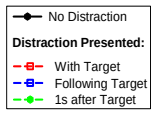

## Results

### 1. Auditory Localization

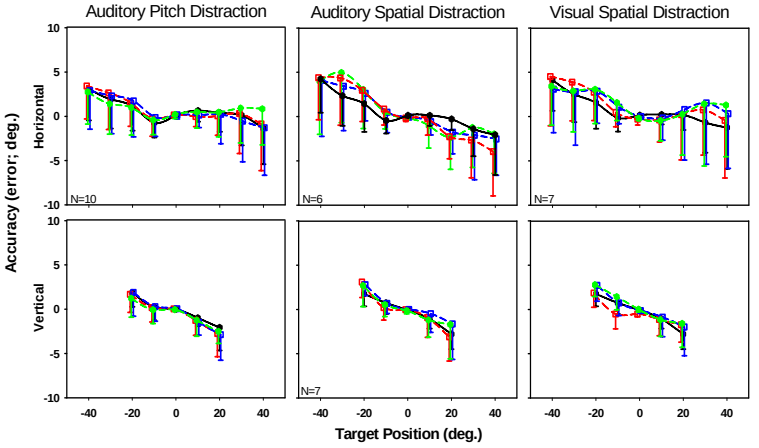



**Horizontal:**
- Horizontal localization of memorized (6 s delay) sounds without distraction proved near accurate (spatial gain, SG=0.98).
- Horizontal sound localization became overestimated in comparison to baseline, if distracted by:
  - discriminating *tone pitch* (SG up to 1.09, P< 0.001)
  - locating *flashing lights* (SG up to 1.12, P< 0.001).
- Timing of distraction presentation did not systematically affect sound localization.

**Vertical:**
Vertical sound localization was undershot (SG=~0.76) and remained similar in the presence of distraction.




### 2. Visual Localization

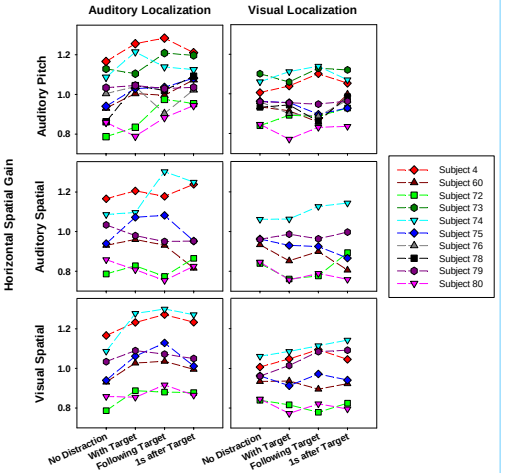



**Horizontal:**
- Horizontal localization of memorized flashes without distraction demonstrated subtle central spatial distortion, accompanied by modest undershoot.
- Visual localization became underestimated (SG=0.89, P=0.001) in comparison to baseline (SG=0.93), when *auditory spatial* distraction was presented simultaneously with the target.

**Vertical:**
Vertical visual localization was slightly undershot (SG=0.90) and remained similar in the presence of distraction.

## Results (Cont.)

### 3. Auditory vs. Visual Localization




## Summary and Conclusions

- **Sound localization of memorized targets (6 s delay) was near accurate in the horizontal plane (spatial gain, SG=~ 1.0) but with undershoot (SG< 1.0) in the vertical plane, when no distraction was present.**
- **Horizontal SG of sound localization increased up to 12% when visual spatial or auditory pitch (non-spatial) distraction tasks were presented, regardless of timing related to target.**
- **Visual localization slightly declined in horizontal SG when auditory spatial distraction occurred simultaneously with the target.**
- **Distraction did not seem to interfere with auditory or visual localization in the vertical plane.**
- **Overall, cross-sensory spatial distracters tended to interfere more with spatial performance than their uni-modal counterparts (particularly in audition), while the opposite was true for non-spatial distraction. Distraction timing did not systematically affect spatial performance.**

**Citations**

1. Baddeley, A.D. 1999. Essentials of Human Memory, first edition. Psychology Press, Hove.
2. Anourova, I. & P. Rama.1999. Selective interference reveals dissociation between auditory memory for location and pitch. *NeuroReport* 10: 3543-3547.
3. Myerson, J., S. Hale, S.H. Rhee, & L. Jenkins. 1999. Selective interference with verbal and spatial working memory in young and older adults. *The Journals of Gerontology* 3: 161-164.
4. Rama P, & A. Poremba (2004). Dissociable functional cortical topographies for working memory maintenance of voice identity and location. *Cerebral Cortex* 14: 768-780.

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