#672

Exploring How Auditory Spatial Continuity Enhances Speech Perception

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Motivation

Continuity of spatial location was recently shown to improve the ability to identify and recall a sequence of target digits presented in a mixture of confusable maskers (Best et al 2008).

Here we present three follow-up experiments that explored the basis of this improvement.

1. First, we examined whether the benefit of spatial continuity was limited to the challenging case in which maskers were all potential targets.

2. In the second experiment, we trained listeners with the spatial trajectory of a moving sequence of digits to examine whether advance knowledge of upcoming target locations enhanced performance.

3. Lastly, we tested whether refinement of spatial selectivity would arise if the target sequence moved but had no discontinuous jumps in location (i.e., the spatial trajectory only included transitions to an adjacent loudspeaker location).

Methods

General

- Experiments were conducted in a single-walled IAC booth with interior dimensions of 12'4" X 13" X 7'6" (l,w,h).

- Subjects were seated in the center facing 5 loudspeakers (evenly spaced from -30° to +30° azimuth)

- Stimuli were digits 1-9 spoken by 15 male talkers.

- Sequences of 4 digits were presented simultaneously from the 5 loudspeakers.

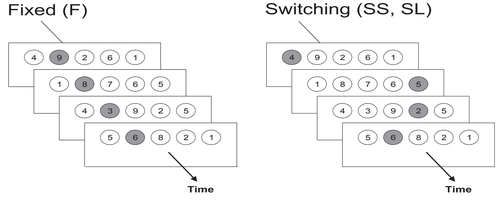
- Silent delays (0, 250, 500, 1000ms) were inserted before each digit to vary overall rate of presentation. A single digit in each temporal position was designated as the target, indicated by an LED located above the target loudpeaker.

Experiment 0 (Original Experiment, n = 5):

- Fixed (F) - target sequence was assigned to a single location per trial (no switch).

- Switch Synchronous (SS) - visual cue turned on and off in synch with the onset and offset of the auditory stimulus in each temporal position.

- Switch Leading (SL) - visual cue came on prior to the auditory stimulus for each temporal position with a lead time equivalent to the silent delay period.



Methods continued

Experiment 1 (Reversed Maskers, n = 4):

- The design was identical to Exp 0 except for the maskers (all non-target digits were time-reversed).
- The target was attenuated by 10dB to increase difficulty.

Experiment 2 (Learned Pattern, n = 6):

- Blocks where the spatial pattern of switching was fixed (PAT) were interleaved with blocks of SS and F.
- These 16 patterns were primed 3 times before each PAT block via the LEDs.
- Due to time constraints, only the 0 ms delay was tested.

Experiment 3 (Smooth Pattern, n = 5):

- The design was identical to Exp 0 except that in SS and SL the target moved smoothly, always transitioning to an adjacent loudspeaker.
- Due to time constraints, 500 ms delay was not tested.

Results

Experiment 0 (Original Experiment)

- Performance in F was better than in SS and SL (Fig 1).
- Rate of presentation had little effect on performance in F (Fig 1), but performance in switching conditions improved at slower rates.
- A leading visual cue (SL) improved performance only at the longest inter-digit delay (Fig 1).
- Performance in F tended to improve for each subsequent digit in the sequence (Fig 2), but this improvement was not evident in SS and SL.

Experiment 1 (Reversed Maskers)

- Results were quite similar to Exp 0 overall.
- Switching still caused a decrease in performance.
- Unlike in Exp 0, there was no advantage of leading visual cue (compare SS and SL).

Experiment 2 (Learned Pattern)

- Results for F and SS replicate the original experiment well.
- For the switching conditions, performance for learned patterns was no better than for random patterns (compare PAT and SS).

Experiment 3 (Smooth Pattern)

- Results were quite simliar to Exp 0 overall.
- Performance for smoothly moving trajectories was still inferior to performance in the fixed condition (compare F and SS).
- Unlike in Exp 0, there was no apparent advantage of the leading visual cue (compare SS and SL).

References

Best V, Ozmeral EJ, Kopco N, and Shinn-Cunningham BG (2008). Object continuity enhances selective auditory attention. PNAS 105(35):13173-13177.

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Figure 1: Scores as a function of inter-digit delay

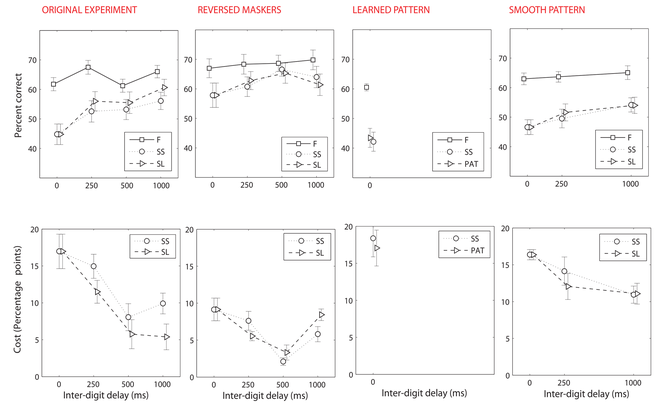
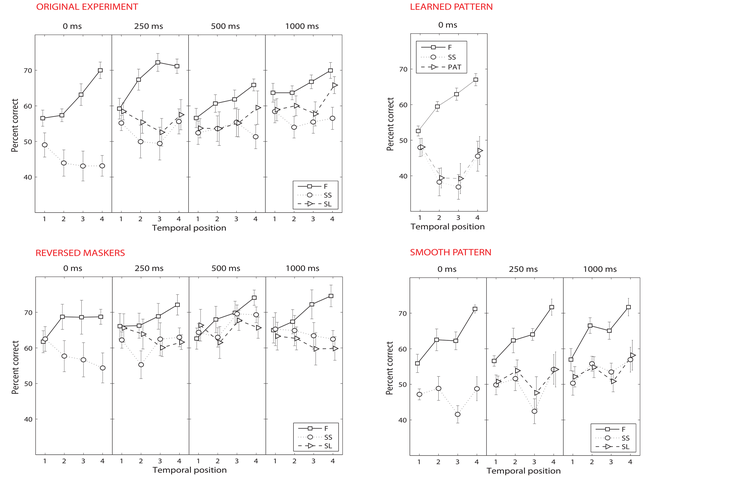


Figure 2: Scores as a function of temporal position



Summary

The results suggest that improvements in selectivity of spatial attention that arise when the target location is fixed from digit to digit cannot be attributed exclusively to:

a) the challenge of filtering out nearby signals that are confusable with the target;

b) the ability to plan where to direct attention well in advance;

c) a freedom from having to redirect attention across large separations in location.