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LRK DRM EDL AKCL

Can you divide attention across two streams or are you rapidly switching between them?

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BACKGROUND

- The ability to divide your attention to two or more areas of interest is important for many human behaviors, and in the last decade has recieved renewed interest.[1]
- Cost of spatially divided attention increases with separation between attended streams.[2]
- Interposing ignored streams between attended streams increases false alarm rate.[3]
- Relevance of visual models of divided attention in the auditory domain is still unclear (FIG. 1).

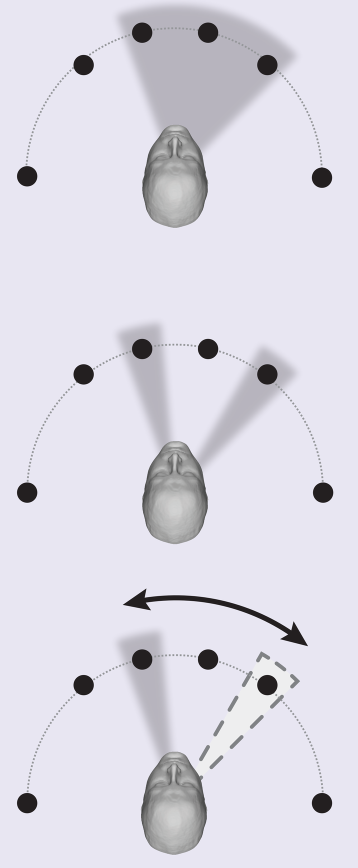


FIGURE 1: Models of divided attention.[2]

QUESTION

- Can temporal information help us to discriminate which listening strategy is used?

HYPOTHESIS

- Performance will improve when targets in attended streams appear in a consistent temporal order, because it facilitates the "rapid switching" strategy of auditory divided attention.

STIMULI

- Alphabet letters AUIOMB (talker *famd0*, ISOLET corpus), monotonized to 200 Hz.
- Letters spatialized to ± 10, 30, 90° via HRTF,[4] with fixed relationship between letter and spatial location (*e.g.*, 'A' always at −90°).
- The letter 'R' occasionally replaced target stream letters; task was button-press response to 'R' in attended spatial streams, and ignoring 'R' in other streams.
- Each trial: 21 "waves" of the 6-letter set
  - **CONTROL CONDITION:** order of letters/spatial streams random within each wave.
  - **TEST CONDITION:** order of letters/spatial streams random for unattended streams, always left-to-right for attended streams.

PROCEDURE

- Five-step training ensured ≥80% proficiency with randomly- and consistently-ordered target streams.
- To-be-attended streams visually cued on each trial.
- N=5 participants heard ten blocks of 8 trials each; half the blocks were control condition, half test condition. Blocks of control stimuli were alternated with test stimuli. Starting block type was counterbalanced across participants; participants were not cued as to which blocks were control or test condition.

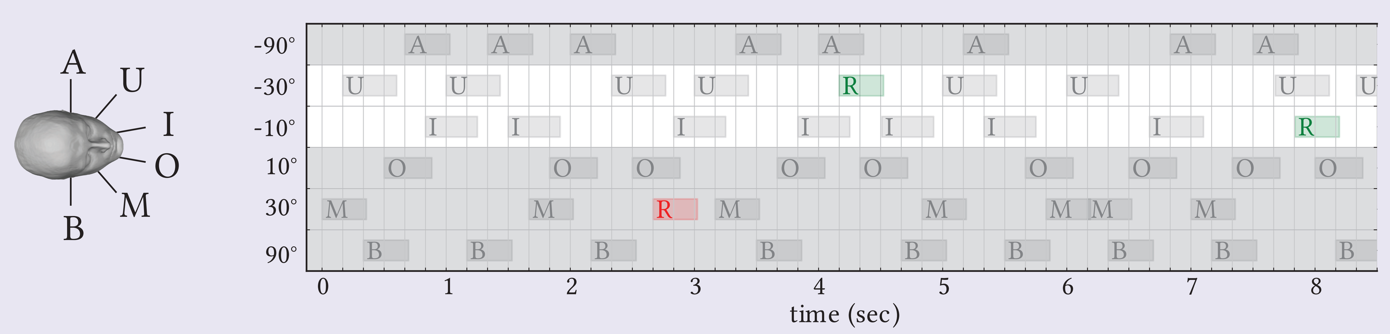


FIGURE 2: Sample trial structure (first eight waves). As shown, the to-be-attended streams (white backgrounds) are spatially adjacent and consistently temporally ordered ('U' stream always precedes 'I' stream in each wave). Small grey rectangles are letter durations; targets are green, foils are red.

RESULTS

- Higher d-prime in trials where target streams have consistent temporal order, (FIG. 3) but only in spatially separated target condition. (FIG. 4)
- Performance increase due to both fewer false alarms and better hit rate. (FIG. 5 lighter bars)
- Listeners with degraded temporal information (no relationship between temporal ordering condition and trial blocking) show lower overall performance and no advantage of temporal ordering in either spatial configuration. (FIG. 6)

DISCUSSION

- Results suggest that listeners can make use of knowledge of temporal ordering when target streams are spatially separated. This is suggestive of a rapid switching strategy and is inconsistent with the broadened and parallel spotlight models.
- The listener strategy used in adjacent target trials is still unknown.

FUTURE WORK

- Vary stream spacing (for denser sampling of azimuth) to better characterize spatial roll-off of "spotlights".
- Manipulate consistency of delay between target stream letters to leverage rhythmic expectations of listener.
- Neuroimaging experiments to provide converging evidence on the question of switching between attended streams (e.g., whether RTPJ is active when to-be-attended streams are spatially separated).[5]

ACKNOWLEDGMENTS

Research supported by R01-DC013260 and T32-DC000033. Special thanks to members of the Laboratory for Auditory Brain Sciences & Neuroengineering for helpful discussions and feedback.

REFERENCES

1 Hafter ER, Sarampalis A, & Loui P, 2007. Auditory attention and filters in auditory perception of sound sources. In Yost WA, Fay RR, & Popper AN (eds.) *Springer Handbook of Auditory Research.* New York: Springer.

2 Best V, Gallun FJ, Ihlefeld A, & Shinn-Cunningham BG (2006). The influence of spatial separation on divided listening. *J. Acoust. Soc. Am.* 120(3), 1506–1516. doi:10.1121/1.2234849

3 Kishline LR, Larson ED, Maddox RK, & Lee AKC (2013). Selective and divided attention: Spatial and pitch 'spotlights' in a non-semantic task. *J. Acoust. Soc. Am.* 134(5), 4230. doi:10.1121/1.4831543

4 Algazi VR, Duda RO, Thompson DM, & Avendano C (2001). The CIPIC HRTF database. In *Proc. WASPAA-2001* (99–102). New Paltz, NY: IEEE. doi:10.1109/ASPAA.2001.969552

5 Larson E, AKC Lee (2014). "Switching auditory attention using spatial and non-spatial features recruits different cortical networks," *Neuroimage* 84: 681-687.

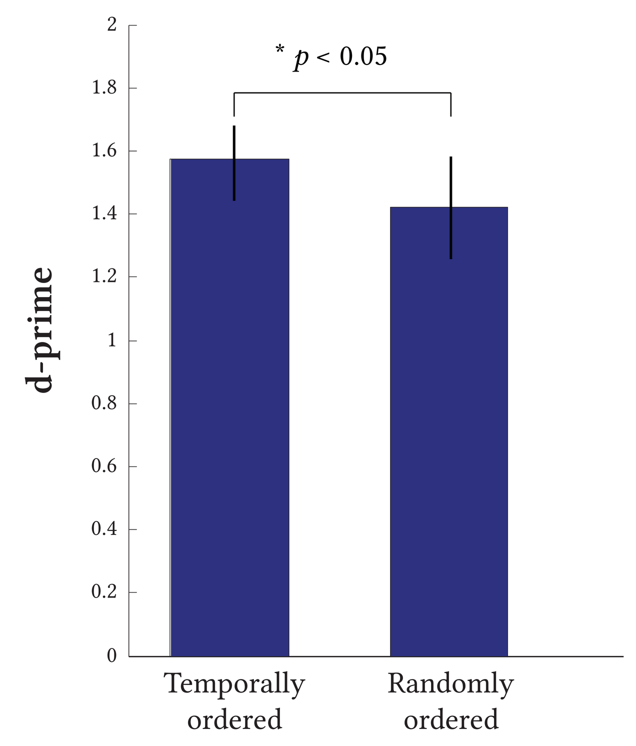


FIGURE 3: Listener performance on trials with and without consistent temporal ordering of target streams.

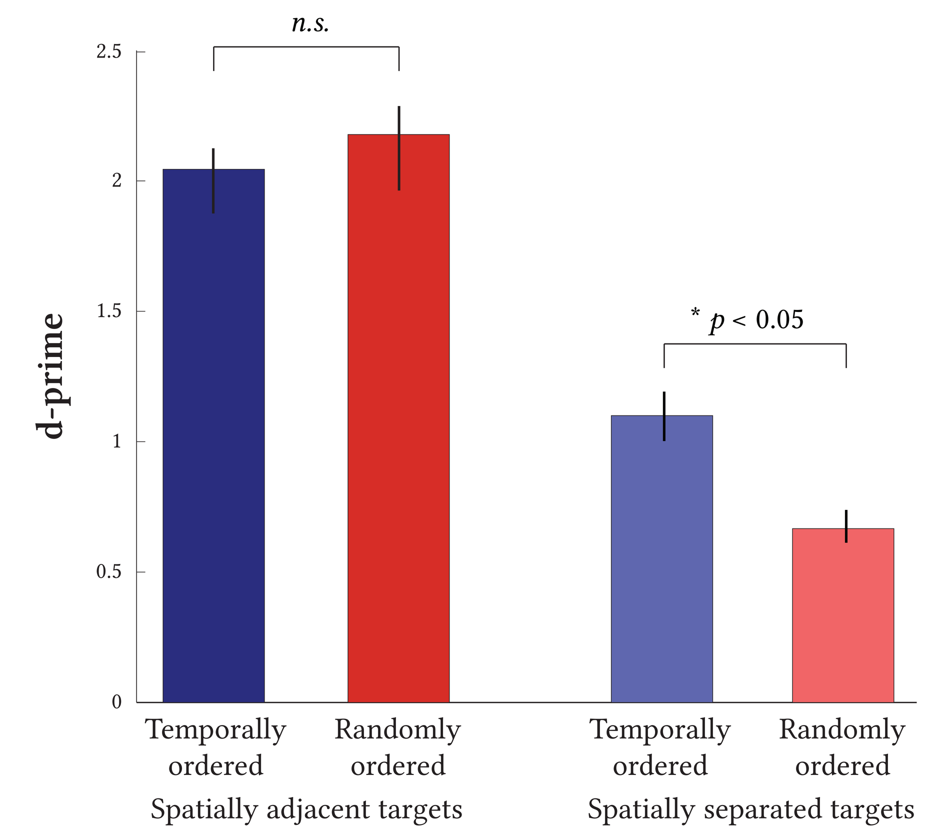
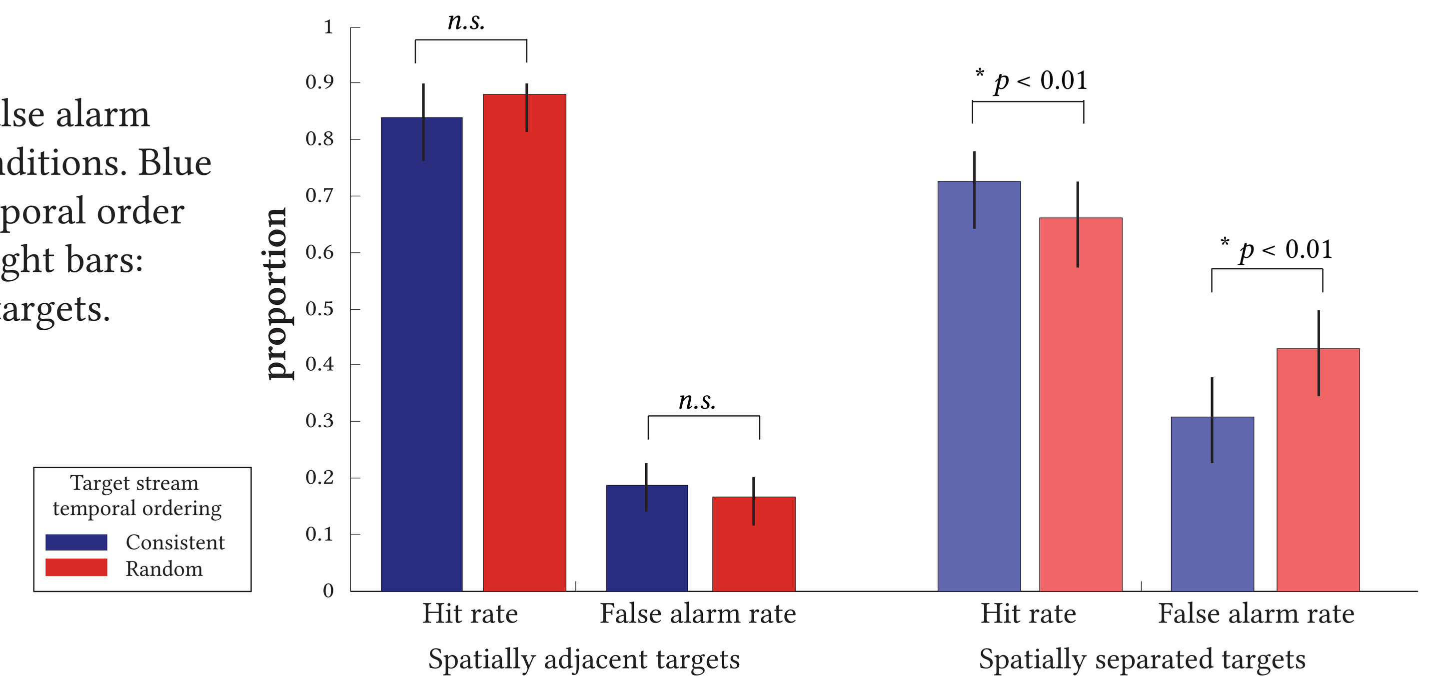


FIGURE 4: Breakdown of listener performance by spatial condition. The advantage due to consistent temporal ordering of target streams is seen only when target streams are spatially separated (light bars).

FIGURE 5: Hit and false alarm rates in the four conditions. Blue bars: consistent temporal order of target streams. Light bars: spatially separated targets.



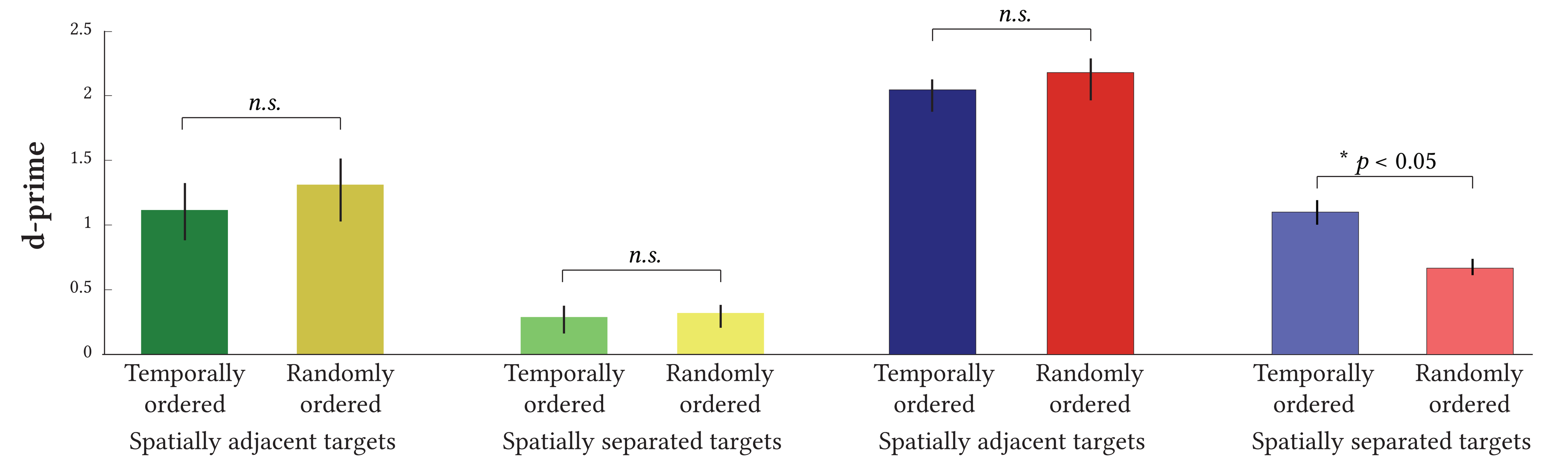


FIGURE 6: Comparison of d-prime scores for subjects who had trial blocks that did not correspond to the temporal ordering condition (green and yellow bars), and subjects for whom the temporal ordering condition was fixed within each block (red and blue bars, cf. fig. 4). For both groups of subjects the block size was 8 trials.