Listener strategy and performance in linguistic and non-linguistic auditory divided attention tasks

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BACKGROUND

- Vision research supports a "spotlight" model of selective and divided attention [1, 2].
- Previous auditory research has not conclusively established which model is most appropriate for audition [3, 4, 5].

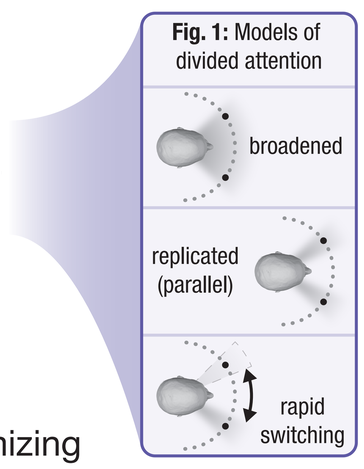


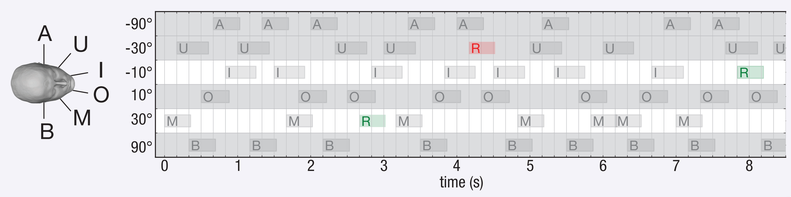
Fig. 1: Models of divided attention

OUR RESEARCH

- A novel auditory paradigm with 4-6 temporally interleaved streams defined by spatial location (simulated by convolution with HRTFs [6]), minimizing spectrotemporal (energetic) masking.
- A series of oddball detection experiments using spoken alphabet letters or monosyllabic words, with manipulations of target spatial separation and linguistic complexity of task.
- **Questions:** which model(s) are accurate representations of listener strategy? How does task type influence listener behavior? How do the cortical circuits for attention and speech processing interact?

EXPERIMENT 1: NUMBER OF ATTENDED STREAMS

Fig. 2: Sample trial structure (first 8 waves). As shown, to-be-attended streams (white backgrounds) are spatially separated. Small grey rectangles are letter durations; targets are green, foils are red.



Methods summary: 6 streams of spoken letters (talker *famd0*, ISOLET corpus) at ±10°, ±30°, ±90° with fixed relationship between letter and angle; targets always "R"; 21 reps. per stream; 1-6 streams visually cued as to-be-attended.

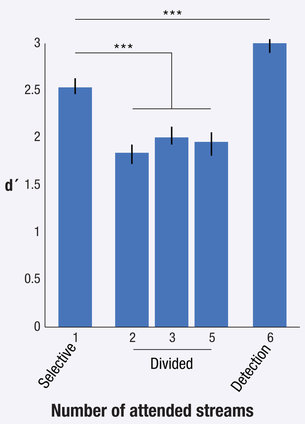
Results: Fig. 3: sensitivity (d′) higest for *detection* (attend all 6 streams); intermediate for *selective attention* (attend 1 stream); lowest for *divided attention* (attend 2/3/5 streams).

In divided attention condition, attended streams adjacent > separated (not shown).

Fig 4: false alarms to streams spatially interposed between attended streams (e.g., the "O" stream in Fig. 2) are more common than FAs to outside streams (the "U" stream).

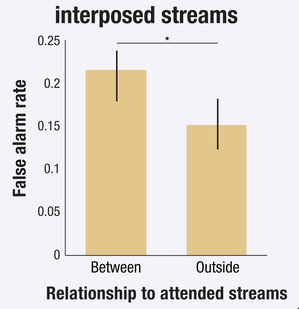
Take-away: it is hard to monitor spatially separated auditory targets while ignoring spatially interposed streams.

Fig. 3: d′ vs. attended streams



n=16

Fig. 4: False alarm rate for interposed streams



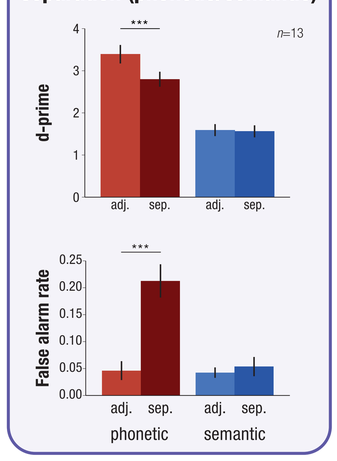
EXPERIMENT 2: PHONETIC vs SEMANTIC DEVIANTS

Methods summary: 4 monosyllabic word streams at ±15°, ±60° with fixed relationship between word/category and angle; 12 reps. per stream; 1-2 streams visually cued as to-be-attended. *Phonetic*: single "base" word per stream; target is any other word. *Semantic*: each stream has 6 related words; targets are semantic deviants.

Results: Replicated adjacent/separated result from Exps. 1 & 2, but only in phonetic task. Effect strongly driven by false alarm rate.

Take-away: the challenge of ignoring interposed streams may depend on task type or difficulty (no elevated false alarm rate to interposed streams in semantic task).

Fig. 5: d′ & FA rate vs. spatial separation (phonetic/semantic)



EXPERIMENT 3: LINGUISTIC TASK COMPLEXITY

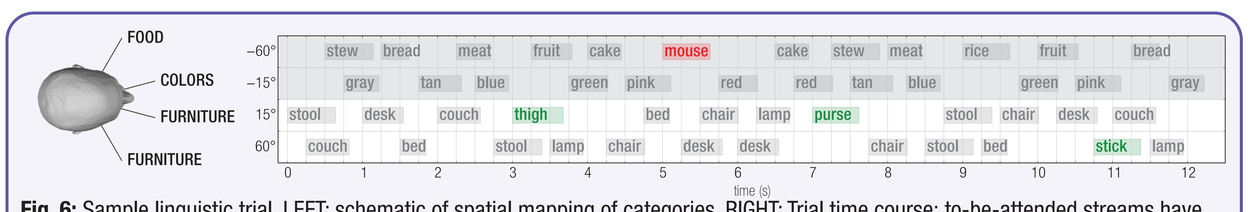


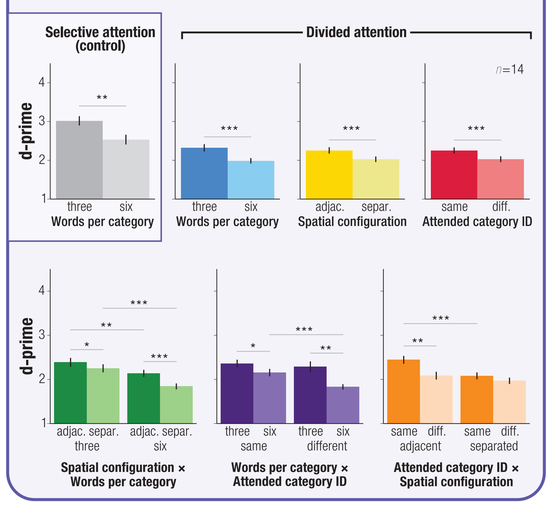
Fig. 6: Sample linguistic trial. LEFT: schematic of spatial mapping of categories. RIGHT: Trial time course; to-be-attended streams have white backgrounds, ignored streams have grey backgrounds; small rectangles are actual word durations; targets are green, foils are red.

Methods summary: 4 word streams, 2 streams attended. Manipulation: congruence of attended streams (same vs. different category) and category size (3 vs. 6 words).

Results: Fig 7: d′ improves when fewer words per category (blue), attended streams are adjacent (yellow), attended streams are same semantic category (red).

Interactions: more words per category → harder when spatially separated (green) or when categories incongruent (purple). Benefit when spatially adjacent categories are congruent (orange).

Fig. 7: d′ main effects & interactions: category size, congruence, and spatial adjacency



GENERAL DISCUSSION

- Listeners may have multiple strategies; models not mutually exclusive.
- **Future work:** Assess listener effort with pupillometry, segregate cognitive load due to linguistic / non-linguistic aspects of the task; M/EEG neuroimaging to identify convergence of attentional / linguistic cortical circuits.

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