

Auditory Metrical Coordination of Attention on a Visual *n*-back Task

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The *n*-back Task

- A popular working memory and attention task.
- Participants view a continuous stream of stimuli (letters, most commonly) and are instructed to press a key when they see a letter that matches the letter they saw *n* letters ago (known as a target).
- Requires participants to maintain and update their mental representation of the target items while responding to each item and dropping irrelevant items from memory.
- Stimuli are presented at a steady pace, lending it an inherent visual rhythm. It is a prime candidate to test the attentional effects of an auditory rhythm on a task unrelated to music or speech.
- This is the first study to examine the effects of an auditory rhythm on *n*-back performance.

Rhythmic/Metric Attending

- Internal rhythms synchronize with the environment, focusing attention on future, periodic points in time.
- The rhythmic coordination of attention is a cognitive process that underlies perception of melodic changes, lexical cues, etc.
- In music, melodic and temporal accents give rise to a sense of meter.
 - Meter provides a rich structure that chunks notes into groups.
 - Metric rhythms are easier to remember and reproduce than nonmetric rhythms.
- Accented beats in a metric rhythm (e.g., the downbeat) are known as “strong” beats
- We pay more attention to events that occur on strong beats.
- This study induces metrical expectations with an auditory rhythm. I examined whether the metrical accent structures created by various rhythms would affect performance on a working memory task in which the letters to be recalled would be presented simultaneously with the rhythm.

Predictions

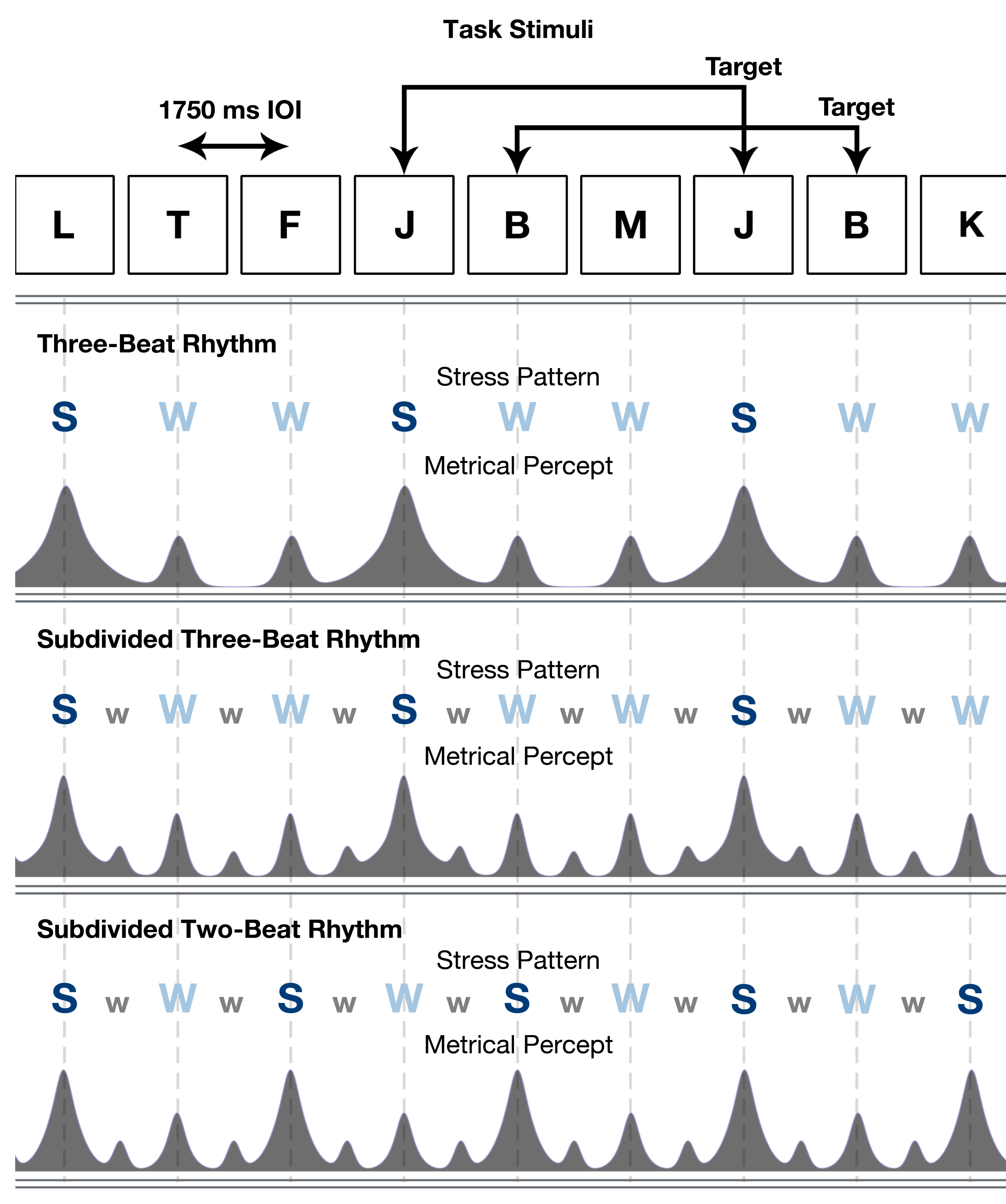
- The three-beat rhythms should provide a three-beat timeline, chunking the 3-back letters, enhancing performance relative to the silent condition.
- The metric expectations arising from exposure to a three-beat metric rhythm should increase attention on strong beats, increasing performance for target letters that landed on these accented notes.
- There should be an interaction between beat presence and musical experience: the presence of the beat should enhance task performance to a greater extent for musically experienced participants than for musically inexperienced participants.

Key References

- Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, 12, 769-786.
- Large, E. W., & Jones, M. R. (1999). The dynamics of attending: How people track time-varying events. *Psychological Review*, 106, 119-159.
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Method

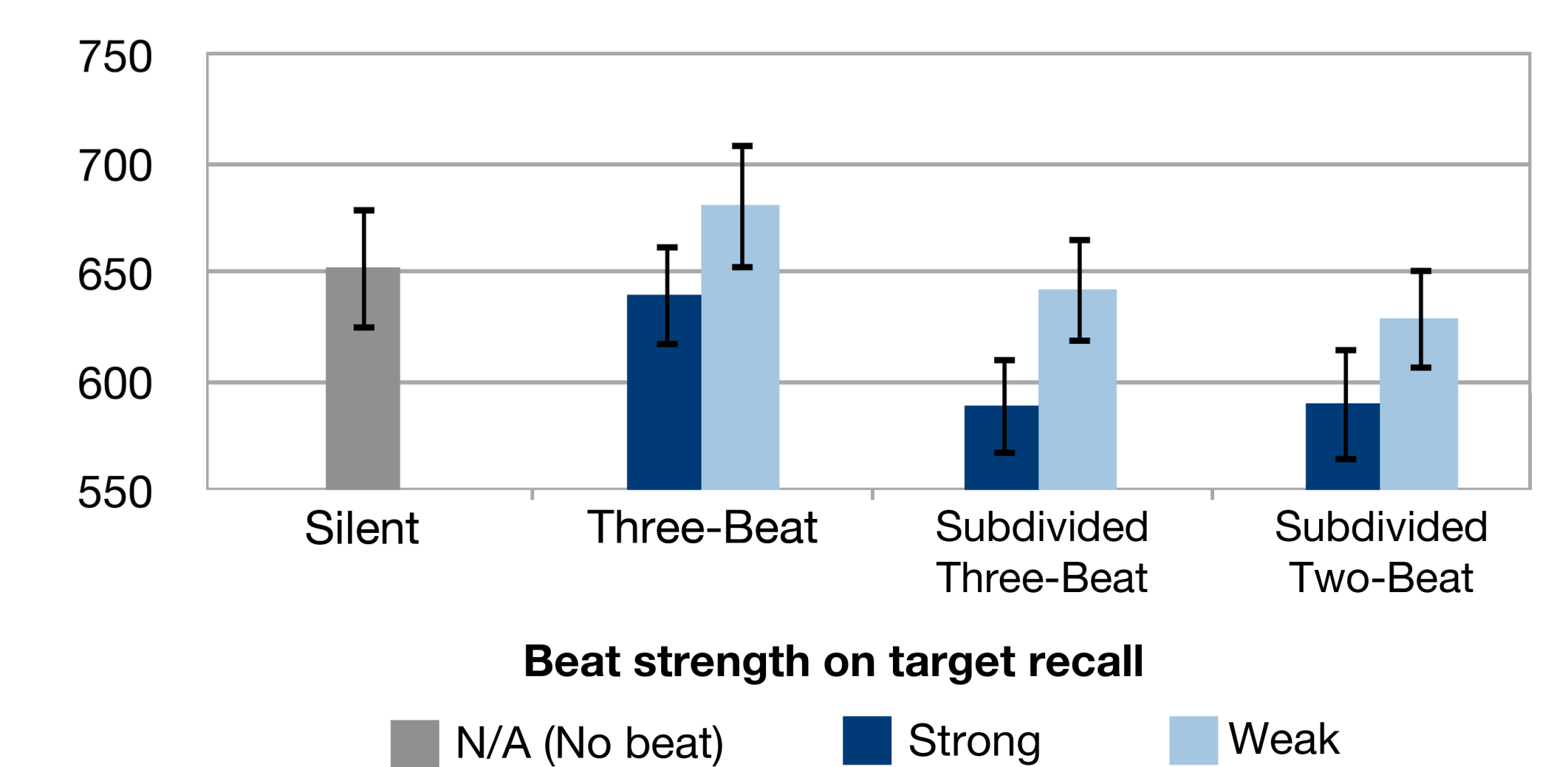
- Participants: 29 Carleton College undergraduates
 - 13 males, 16 females, $M_{age} = 20.7$ years, age range: 18-24 years
 - 14 *low musical experience* participants (0-9 years total experience)
 - 15 *high musical experience* participants (11-41 years total experience)
- Presented letters on a computer screen, one at a time.
- A 3-back task: Participants pressed a button when the letter on-screen matched the letter presented three letters ago.
- All participants were exposed, in counterbalanced order, to four rhythm conditions:
 - A simple 3-beat rhythm, with beats always coinciding with letters.
 - A subdivided 3-beat rhythm with intermediate beats, doubling the speed of the auditory rhythm, making it more perceptually salient.
 - A subdivided 2-beat rhythm with intermediate beats.
 - Silence (no rhythm)
- Response times (RTs) and detection rates (d' scores) were recorded.



Results

- Effects of rhythm type and beat strength on RT and d' scores were examined with a 4 X 2 repeated-measure analysis of variance.
- Main effect for beat strength on RT, $F(1, 26) = 10.39, p = .003$. Strong beat targets were detected more rapidly than weak beat targets.
- Main effect for rhythm type on RT, $F(3, 78) = 4.76, p = .004$. The subdivided rhythms, that were expected to be more rhythmically salient than the nonsubdivided three-beat rhythm, produced faster RTs than both the silent condition and the nonsubdivided three-beat condition.

Response times on accurate target detection (ms)



- No main effects for rhythm type or beat strength on d' scores.
- Main effect for years musical experience on d' scores, $F(1, 26) = 6.69, p = .016$. Performance in all rhythm conditions, as measured by d' scores, was higher for participants with high musical experience.

Discussion

- Participants respond significantly more quickly to targets landing on strong beats.
- Participants respond significantly more quickly to targets in the faster subdivided rhythms, regardless of beat strength.
- Do faster RTs indicate enhanced attention to the task, or a response to the rhythm alone? Participants' tendency to respond faster to strong beats and to faster rhythms did not *decrease* d' scores. It is my position that the effects on RT indicate increased attention given to strong beat targets.
- Musically experienced participants were better at the task in all conditions; notably, they were better at the task even when the beat was not present.
 - Consider the nature of sight-reading. Sight-reading involves recalling, processing, and executing previously seen notes, while storing new ones. This is not dissimilar to the processes used during the *n*-back task, in which participants recall, process, and match previously seen letters, while storing new ones.
 - This result begs further questioning regarding cognitive structures that may be enhanced by musical training.
- The success of this experiment suggests that there may be future success in applying an auditory rhythm to other non-musical contexts. Findings about metric coordination of attention have been applied to speech and music, but rarely to cognitive tasks. Seldom has the question been asked, do we think rhythmically? This is an area of research that is wide open, and ripe for exploration.