# Pupil size reveals the cognitive load involved in processing rhythmic stimuli of various tempi and complexity

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## Introduction

The processing of rhythmic information is essential for complex human behaviors like language, music, and dance. It depends on temporal predictability and requires attentional and cognitive resources to extract structures such as the beat. Since attention is limited, the Dynamical Systems Theory suggests that perception and attention align brain oscillations with external rhythms to optimize information processing (Spiech et al., 2024).

To investigate these attentional processes, pupil size can be recorded during auditory-motor synchronization tasks. Participants tap in time with auditory stimuli while pupillometry measures pupil dilation, a proxy for cognitive effort linked to noradrenergic activity from the locus coeruleus (Sirois & Brisson, 2014). Pupillometry is thus a robust and non-invasive tool to assess attentional load.

Temporal processing differs between individuals, notably through their Spontaneous Motor Tempo (SMT)—the natural rhythm of movements like walking or speaking. Synchronizing with tempi close to one's SMT requires less effort and results in smaller pupil dilation. In contrast, synchronizing with rhythms far from SMT or with medium-complexity rhythms leads to larger pupil responses, reflecting increased cognitive demand (Spiech, Hope, Bégel, 2024). Active synchronization also induces greater dilation than passive listening.

This study aims to evaluate the cognitive load of synchronizing with syncopated rhythms of varying complexity and tempi, compared to passive listening. We hypothesize that more complex, off-SMT rhythms will elicit greater pupil dilation due to increased attentional demands.

## Méthode

Around 20 adults will be broadly recruited, excluding those with known neurological, developmental, or motor disorders. A questionnaire will collect data on prior musical experience. Pupillometry recordings will use the Pupil Core system from Pupil Labs. Participants' SMT will be recorded and processed using a custom script, and after calibration participants will listen to and synchronize with two rhythm types: strong (non-syncopated), and weak (syncopated). The stimuli will be created using MuseScore.

Pupil data will be preprocessed with another custom script to focus on rapid, stimulus-locked changes. We will remove slow fluctuations caused by environmental or internal factors, and normalize the data across conditions to ensure comparability

**Résultats**

Results are still in analysis.

**Conclusions/Perspectives**

We anticipate observing greater pupil dilation when participants perform the synchronization task with more complex rhythms, even if their performance remains consistent across all conditions, reflecting greater cognitive attention. Additionally, since synchronizing with a tempo far from a participant's SMT demands even more cognitive effort, we expect an interaction between rhythm complexity and tempi. Specifically, we predict an even greater pupil dilation when participants synchronize with a complex rhythm that deviates significantly from their personal SMT.

These findings will be interpreted in the context of the dynamic theory of attention, perception, and action, which postulates that the human brain allocates attention at specific moments in an oscillatory manner to optimize environmental processing. Simple rhythms are expected to be naturally aligned with oscillatory attentional processes, reducing attentional load for synchronization, whereas more complex rhythms would demand greater cognitive resources.

These results would provide valuable insights into the sensorimotor and cognitive processes involved in processing temporal information. This is particularly relevant because most external stimuli, such as language, are inherently syncopated while still presenting an intrinsic rhythm. Extracting rhythmic information from these stimuli is essential for highly complex human functions, including verbal and non-verbal communication. A deeper understanding of these processes could ultimately contribute to the rehabilitation of such intricate cognitive functions in cases of neurodevelopmental, neuropsychiatric, or neurodegenerative disorders.

**Références**

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