

Effects of musical tempo and spontaneous rates on pain perception



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Introduction

- Music can reduce pain perception by regulating emotion and arousal (Roy et al., 2008; 2012).
- Structural properties of music such as rhythm and tempo influence autonomic functions and arousal (Wright et al., 2022).
- Spontaneous rates at which people tap, clap, or perform music show large individual differences (Zamm et al., 2016; Palmer et al., 2019).
- Musicians drift in tempo toward their spontaneous rate (Zamm et al., 2018).
- Spontaneous rates consistent with attractor point of optimal energy efficiency (Béglé et al., 2022; Hoyt & Taylor, 1981; Palmer et al., 2022; Pfordresher et al., 2021).

Research Question

- How do musical tempo and spontaneous rates affect pain perception?

Hypothesis

- Music presented at tempi close to an individual's spontaneous production rate (SPR) will reduce pain perception more effectively than music at other tempi, following dynamical systems principles.

Method

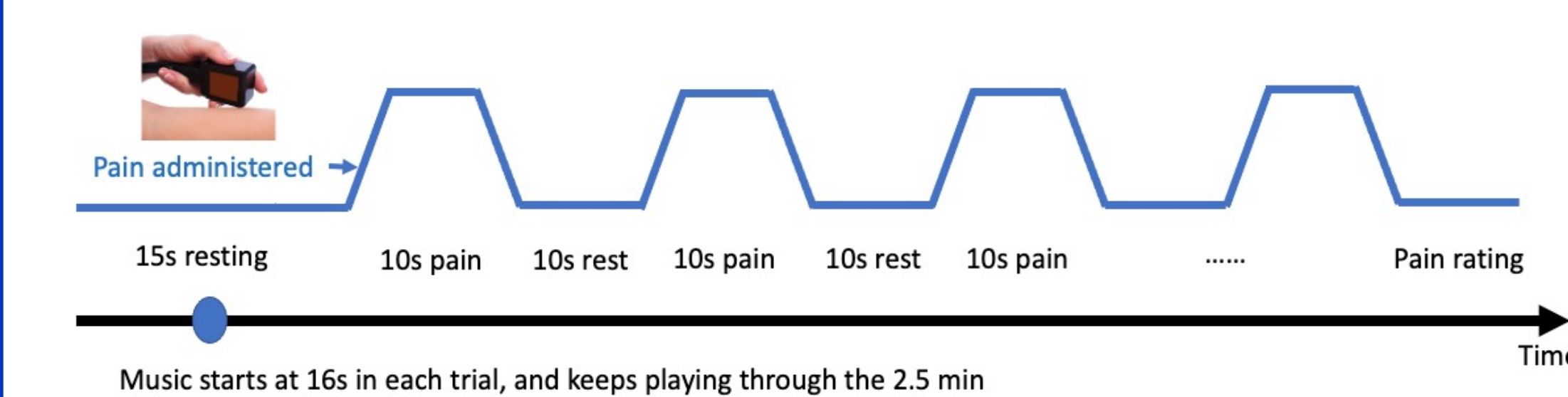
Participants

- 60 participants (49 Females, 10 Males, 1 Agender)
- No history of pain-related disorders, alcohol or substance abuse, or hearing disorders
- 20 classified as Musicians (training years ≥ 6)
- 40 classified as Nonmusicians (training years < 6)

Design

- Each subject receives 4 conditions, counterbalanced order, with pain administered during:
No music; tempo at SPR; SPR +15%; SPR - 15%

Procedure



Tasks:

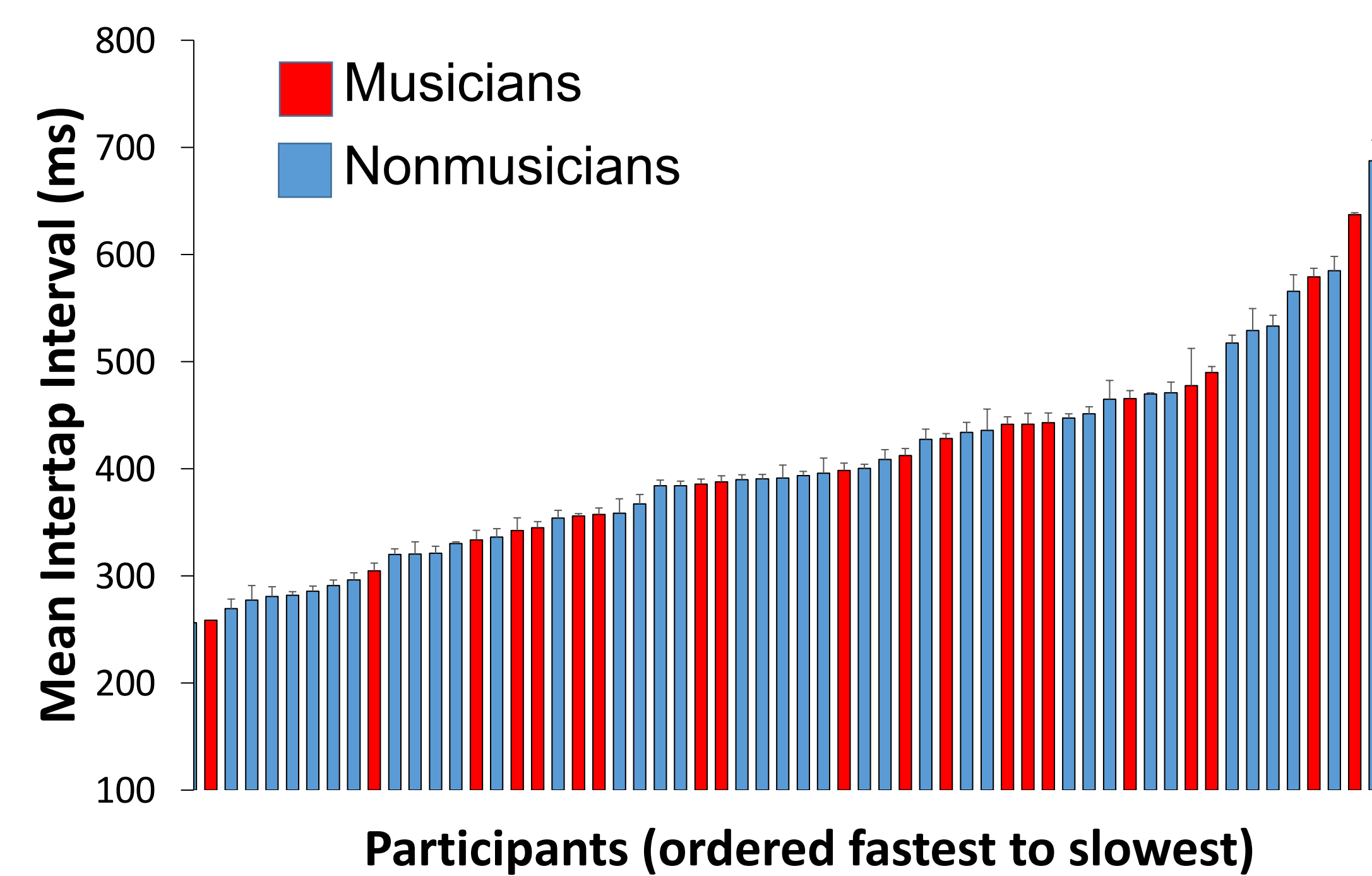
- Each individual's spontaneous rate determined with tapping task (produce familiar melody not used in study at comfortable rate). SPR = mean intertap interval (ms).
- Individuals indicate preferred musical style for the study
Popular = 30, Classical = 14, Dance = 10, International = 6
- Tempo for preferred style set to each individual's
SPR; SPR + 15%; SPR - 15%; No music
- Individual pain threshold = heat thermode on inner arm set to 40% of individual's subjective pain threshold

Perceptual Ratings:

- Participants rate perceived pain intensity (100-point scale) after each trial
- Participants rate the music preference (7-point Likert scale) after each block of trials with the same music

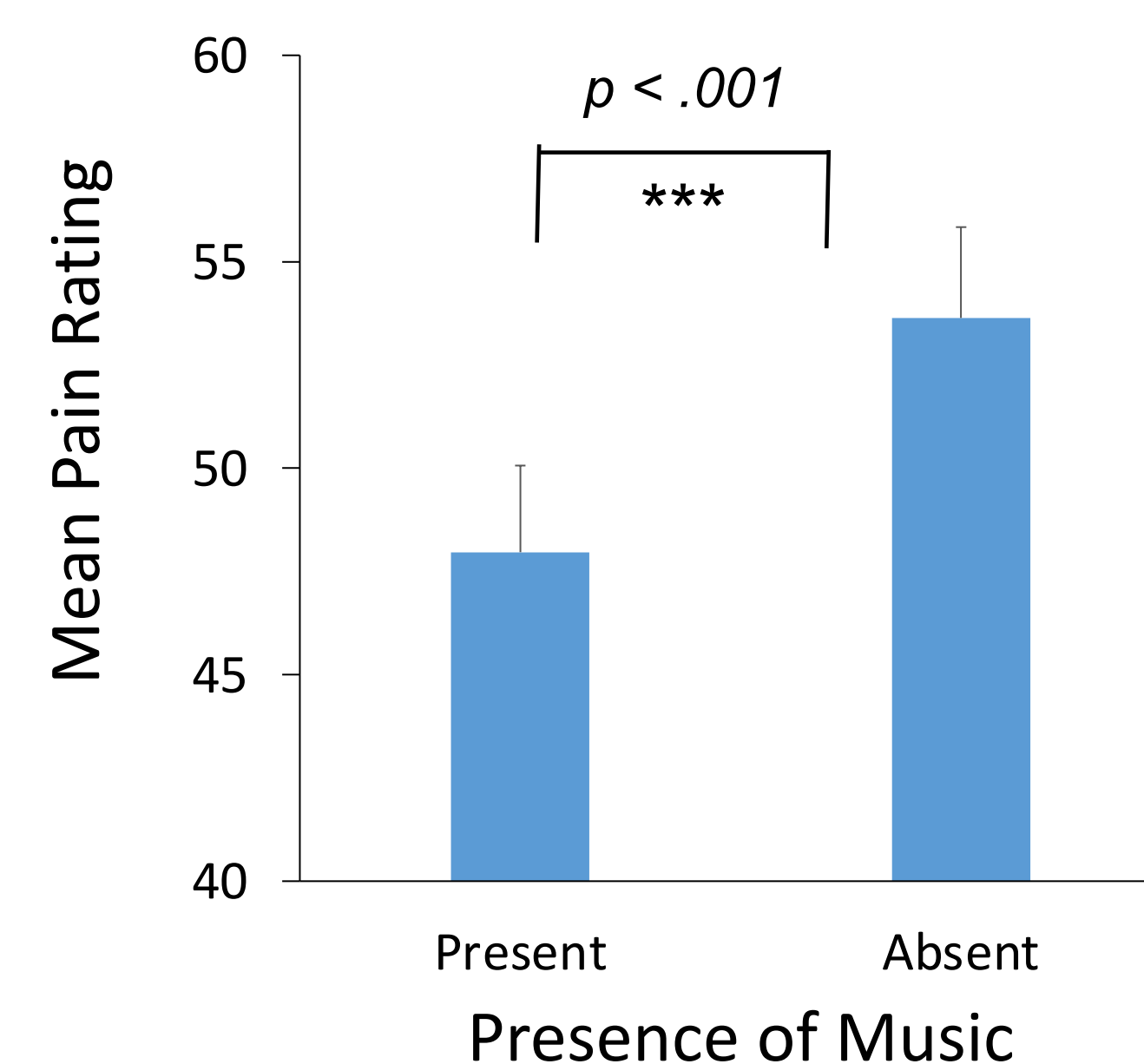
Results

Participants' Spontaneous Production Rates



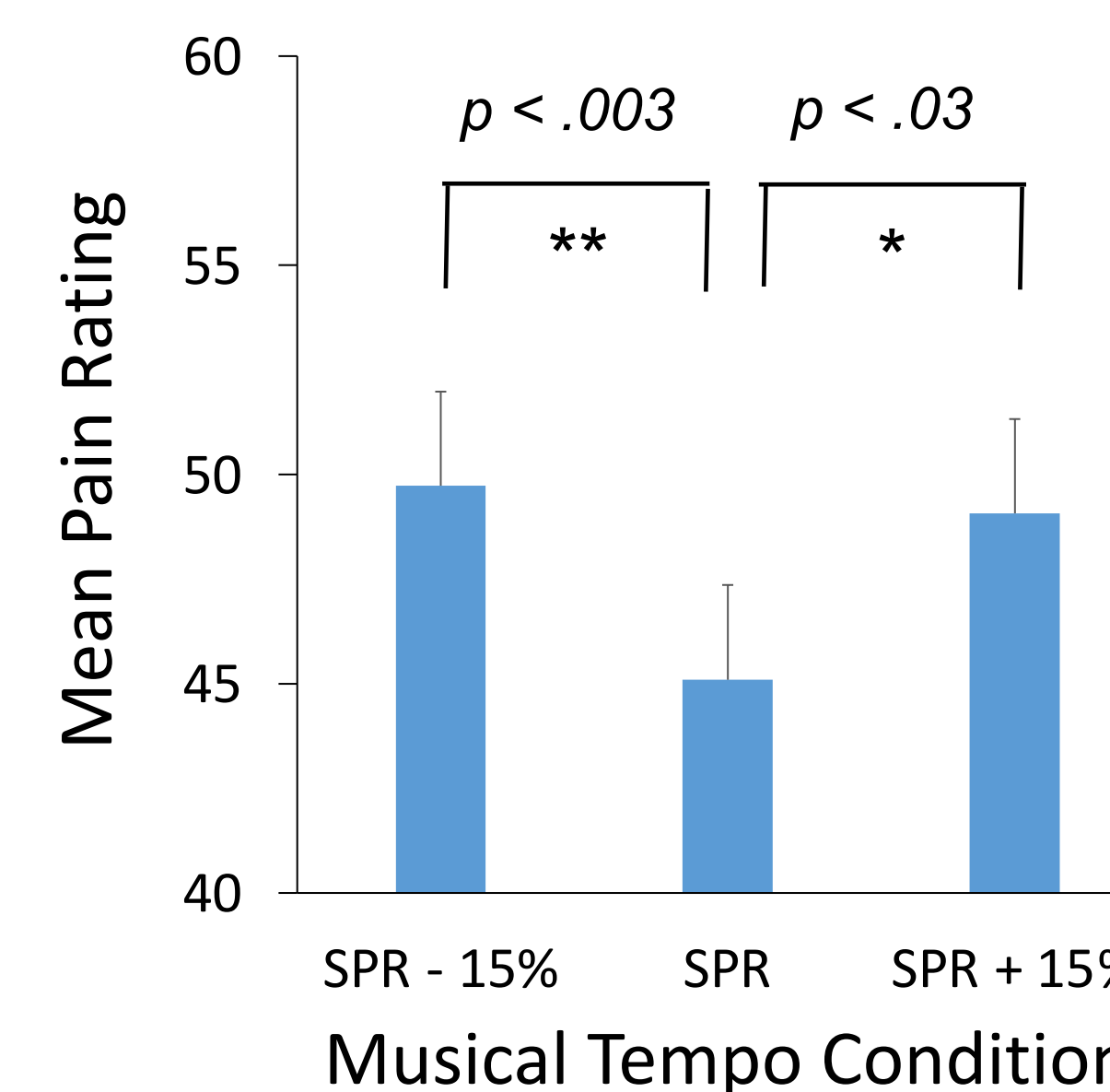
Large individual differences in optimal musical tempo
Musicians' and nonmusicians' SPRs do not differ $t(58) = 0.31, p = 0.76$

Music Reduces Pain Perception SPR Tempo reduces Pain Perception



Reduced pain perception in presence of music

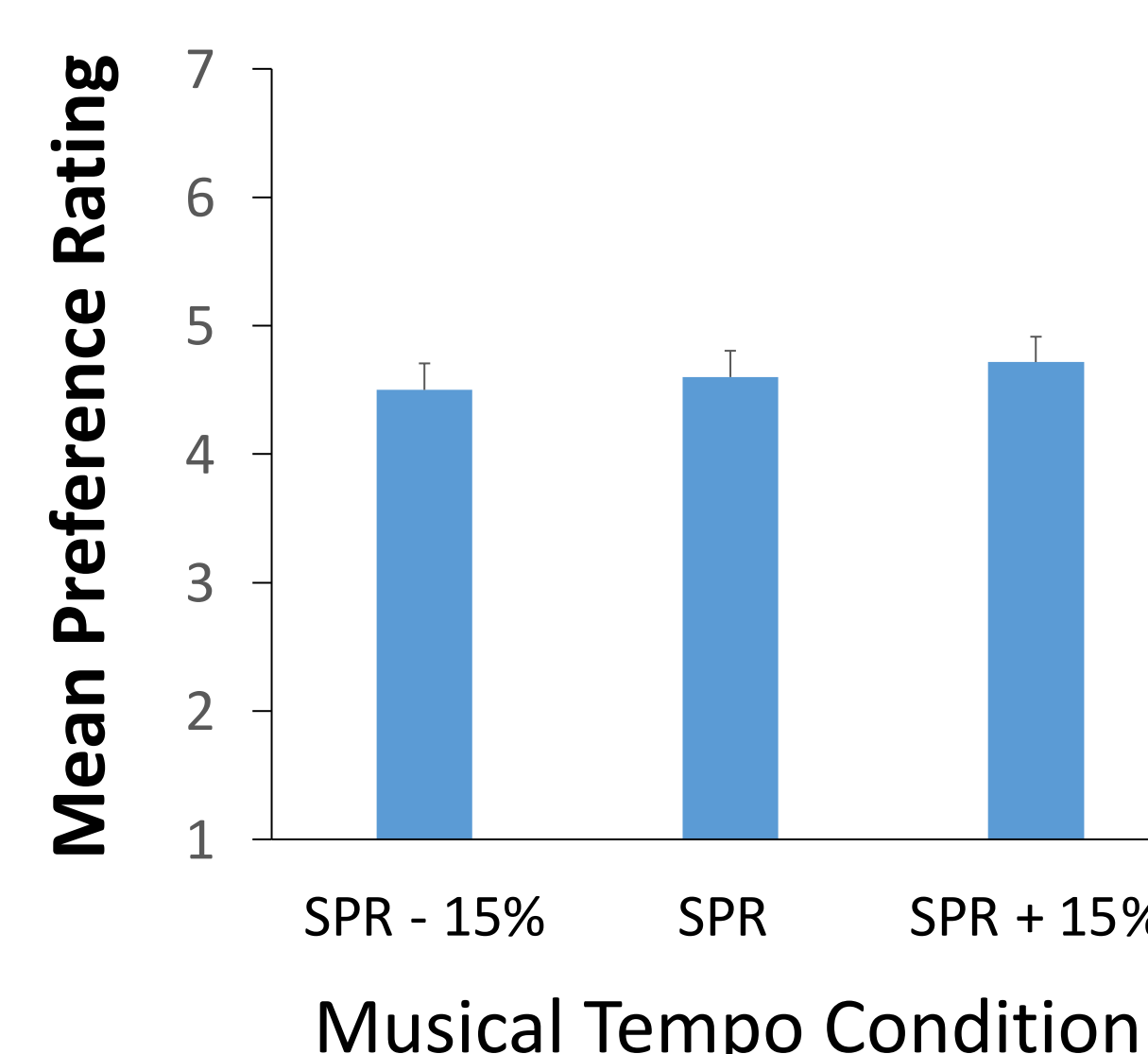
$F(1, 59) = 21.82, p < .001$



Reduced pain perception when musical tempo = SPR

$F(2, 118) = 6.09, p = .003$

Musical Preference Ratings



Preference Ratings did not differ across Musical Tempo conditions

$F(2, 118) = 1.025, p = 0.362$

Discussion

How do musical tempo and spontaneous rates affect pain perception?

- Presence of music reduced perceived pain
- replicates previous findings (Roy et al (2008; 2012)
- Music presented at individuals' spontaneous production rates most reduced pain perception
Consistent with tempo as point of minimal energy expenditure
- Musical tempo preferences and style choices did not account for reduced pain perception

A proposed mechanism to explain the findings:

- Individual spontaneous rates =
- States of most energy efficiency =
- Most entrainment of endogenous rhythms

Future Directions

- Neural and physiological measures taken during music listening, such as steady-state EEG and respiration, may reveal how entrainment of endogenous rhythms at specific frequencies reduces pain perception
- Future studies may investigate role of additional music attributes in pain perception, such as rhythmic patterns and timbral densities

References

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Acknowledgments



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