Title: Auditory stimulation during sleep transiently increases delta power and all-night proportion of NREM stage 3 sleep while preserving total sleep time and continuity

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Background: Phase-locked auditory stimulation during NREM sleep increases power spectral density (PSD) in the delta frequency range of the EEG ("deep sleep enhancement"). We manually administered sounds during both N2 and N3 sleep, not phase-locked to delta waves, to evaluate an "Enhance" and "Disrupt" condition night relative to a night without acoustic stimuli ("Sham"). We hypothesized that an Enhance condition with sound stimuli would induce more %N3 sleep compared to Sham; and that a Disrupt condition would reduce %N3 compared to Sham, and induce more neurocortical arousals.

Methods/Analyses: Participants (8 healthy adults 36-49, 5 female) slept 4 consecutive nights in an inpatient lab with polysomnography. Nights 1 & 3 (Habituation, Sham) were nonintervention nights; nights 2 & 4 were Enhance or Disrupt conditions (random order). Enhance sounds (pink noise pulses presented at an interval of .8 Hz) were played during N2 and N3. Disrupt sounds (environmental sounds known to cause arousals) were played during N2, N3, and REM. In order to further characterize the specificity of acoustic stimuli, the disrupt sounds varied in inter-burst interval, sound type, frequency, and pressure level. PSD in the delta band (.5-4Hz) of the EEG was extracted for each night and evaluated during N2, N3, and across all sleep stages. Delta band PSD and sleep outcomes were compared across Sham, Disrupt, and Enhance using mixed linear modeling for repeated measures and included the interaction between condition and order of Enhance/Disrupt.

Results: Sounds were played for 24.8% of TST on Disrupt and 25.2% of TST on Enhance (*n.s.*). Total Sleep TIme did not differ among conditions. When Enhance stimuli were presented during N2 or N3, Delta PSD was transiently increased. There was a significant interaction between condition and the order of Disrupt or Enhance ($p<.01$) on %N3 sleep where the %N3 sleep was increased in Enhance vs. Sham when Enhance was presented before Disrupt ($p<.05$). Sleep continuity did not differ between Enhance and Sham (*n.s.*). In contrast, sleep continuity was worse on Disrupt vs. Sham ($p<.0001$).

Conclusions:
Despite playing sound for a similar proportion of TST as Disrupt, sleep continuity did not suffer on the Enhance night. We were able to preserve TST and increase %N3 by playing pink noise sounds during N2 & N3, which has not yet been reported in conjunction with delta-band PSD increases. We attribute the significant order interaction with condition to a rebound effect on the Sham nights that followed Disrupt, rendering Sham similar to "enhanced" sleep.