Supplementary Materials for

States and traits of neural irregularity in the age-varying human brain

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SI Methods

Pre-experiment adaptive tracking task

Before the main experiment started, an adaptive tracking pitch discrimination procedure was performed to make sure that participants (i) were familiar with the task and (ii) based their decisions on perceived pitch differences only. This becomes necessary when comparing identical stimuli, since fluctuations in the perception of durations and loudness are not only possible but have been reported previously (Bernasconi et al. 2011). Before the adaptive tracking task, participants were encouraged to complete 20 practice trials to familiarize themselves with the task. Practice trials consisted of one 650 Hz and one 620 Hz tone, presented in random order (corresponding to the stimuli that were used as a start level of the adaptive tracking paradigm) and involved auditory feedback which was "true" in this case. Subjects were given the chance to ask questions regarding the task before the adaptive tracking paradigm started.

The ensuing adaptive tracking consisted of 30 trials. The same task as for the practice trials was used but pitch differences between the two tones of each pair changed according to an adaptive, one-up–one-down staircase procedure targeting a 50%-correct threshold (Levitt 1971). After completing the adaptive tracking, subjects were informed via written instructions on the screen that the level of difficulty during the main experiment would be very high (i.e., pitch differences between tones would be small) and that accuracy scores slightly above chance would denote reasonably good performance.

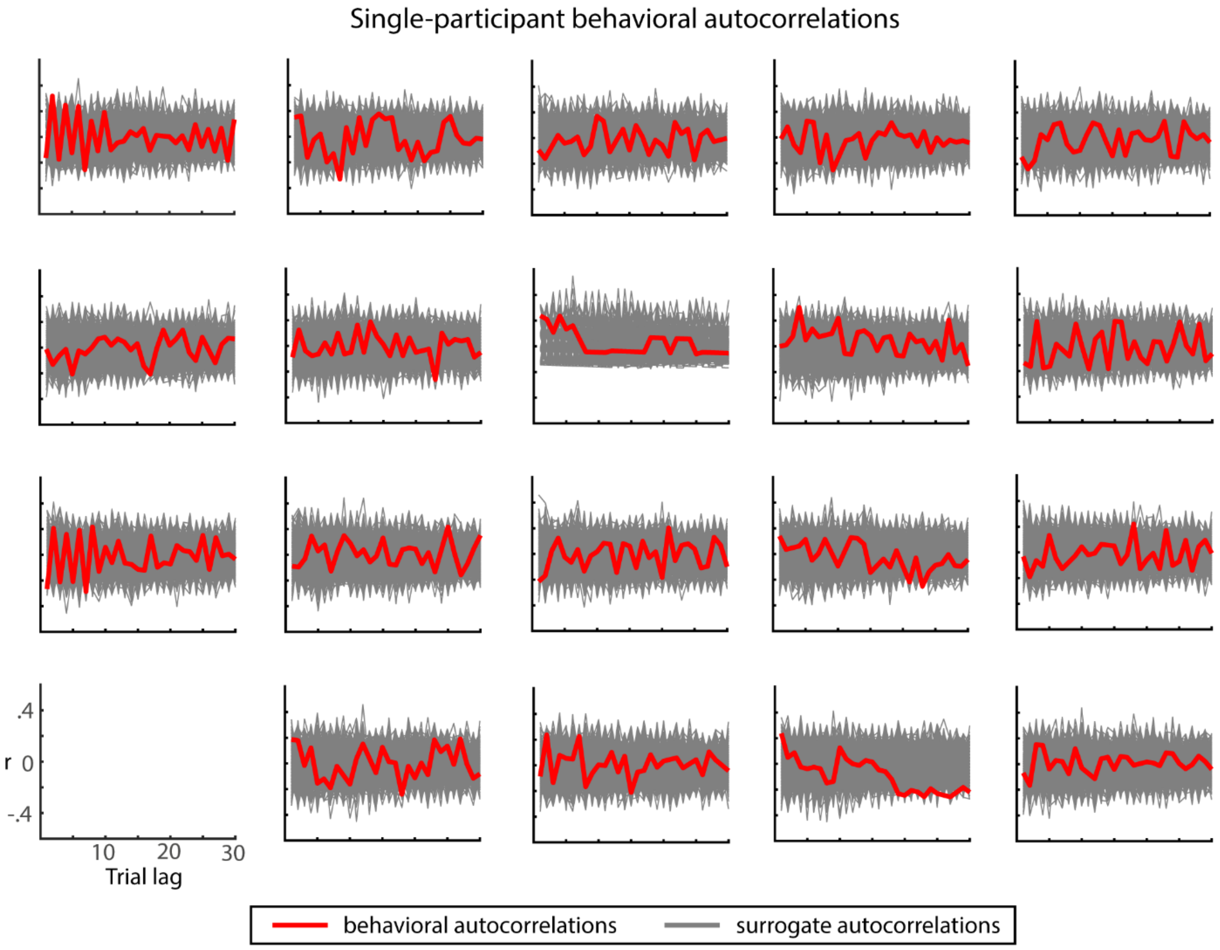

Figure S1. Response sequences of single participants are not substantially autocorrelated. Lagged autocorrelation coefficients (r) of responses are shown for each participant (red lines), for trial lags of 1 to 30. Surrogate autocorrelations (1000 iterations) resulting from permuting every single participant's responses before computing autocorrelations are shown in grey. Note that the observed lagged correlation coefficients of actual responses are well exceeded by surrogate correlations for all participants, indicating no substantial autoregressive structure in the behavioral response patterns.

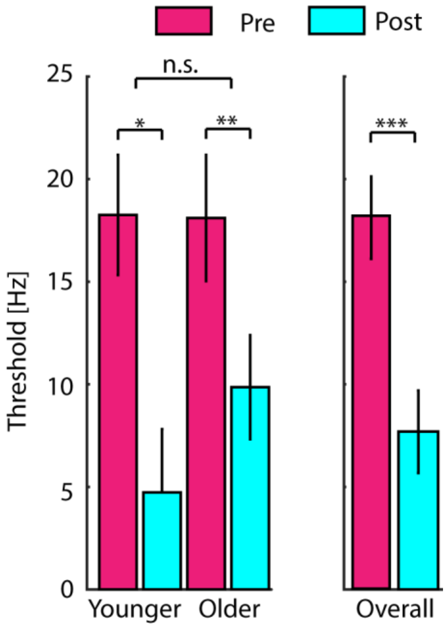

Figure S2. Lowered frequency discrimination thresholds after the main experiment. Frequency discrimination thresholds for 50% correct pitch discrimination were assessed using an adaptive tracking procedure before (pink, Pre) and after (cyan, Post) the main experiment. Groups of younger (19–37 years) and older participants (41–74 years) displayed significant decreases in thresholds (left, Post vs. Pre), which did not differ between age groups (and thus obviously were also present over all participants, right). Error bars show ±1 between-subject SEM. * $p < .05$; ** $p < .01$; *** $p < .0005$

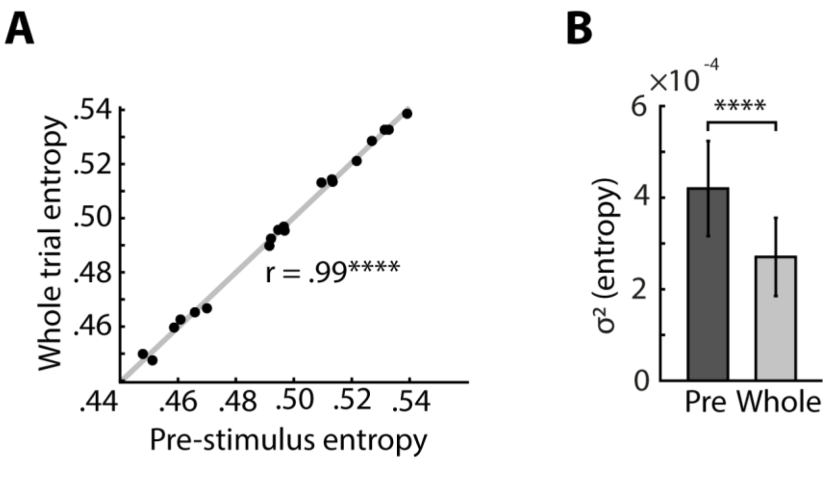

Figure S3. Comparing EEG-entropy between different time windows. **A**, EEG-entropy (electrode Cz) averaged across all trials in the pre-stimulus time interval (–2000 to 2000 ms) and average entropy during the whole trial (–.4 to –.1 ms) are highly correlated. Dots represent single participants, least squares line shown in grey. **B**, The across-trial variance (σ^2) of pre-stimulus averages (dark grey) is significantly higher than the variance of whole-trial averages (light grey). **** $p < 1 \times 10^{-5}$

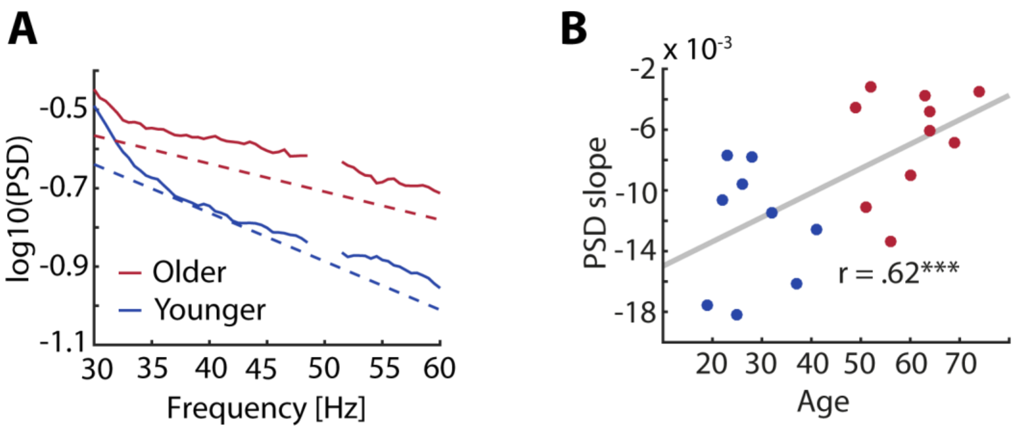

Figure S4. PSD slopes between 30 and 60 Hz also become more positive with age. **A**, Power spectral density (electrode Cz) between 30 and 60 Hz is shown in semi log space for older (red) and younger (blue) participants separately alongside the respective average slope, resulting from the average of linear fits for individual participants across frequencies (dashed lines). Slopes of older participants appear shallower on average. Power between 48.5 and 51.5 Hz represented line noise, thus was excluded for the fit and is also omitted here for visualization. Note that the offsets between linear fits and actual PSD curves are driven by the data of one participant per group, displaying a highly negative intercept. **B**, PSD slopes become less negative (shallower) with increasing age. Again, older subjects are shown in red, younger subjects in blue. *** $p \leq .005$

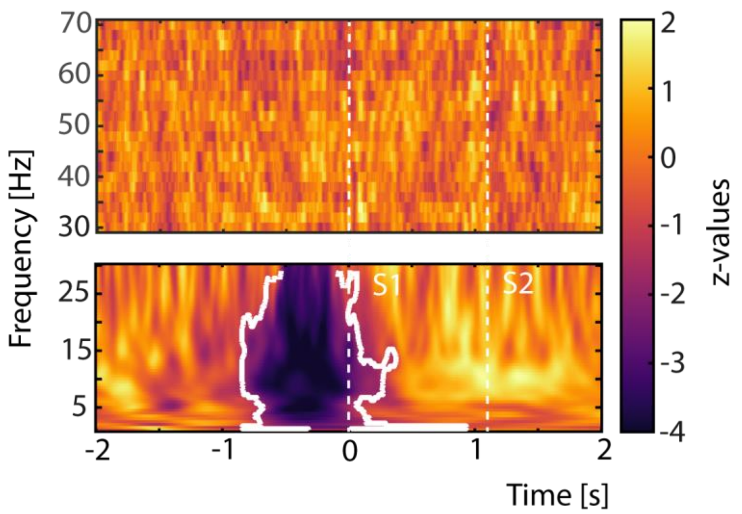

Figure S5. Pre-stimulus entropy tracks low-frequency but not high-frequency power. Z-values from a cluster-based permutation test, modeling the linear increase in oscillatory power across four bins of increasing pre-stimulus entropy, are shown. Note that the bottom panel is replotted from Fig. 3 to allow a comparison to the upper panel (30 - 70 Hz). No significant cluster was found for frequencies higher than 28 Hz.

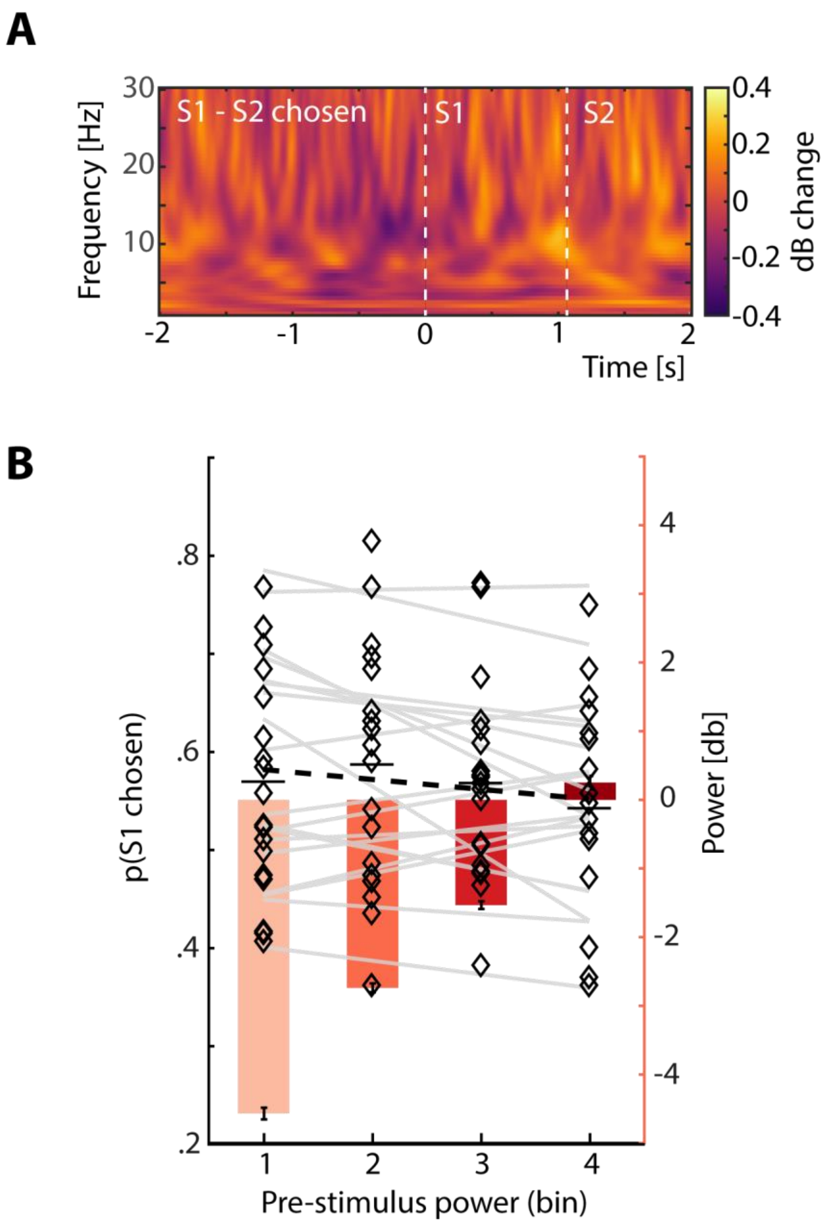

Figure S6. Pre-stimulus power does not differ between decisions. **A**, Difference in grand average power (dB change, baseline between −2 and −1 s) between trials during which S1 (left) and trials during which S2 (right) was chosen. No significant cluster found (all p >.05). **B,** Probability of choosing S1 is unaffected by pre-stimulus low frequency power. The probability of choosing S1 is shown for each subject and power bin (diamonds). Grey lines depict single-subject slopes fitted to probabilities across bins for visualization. Slopes were not different from zero on average (black dashed line, $p = .1$). Bars of darkening orange represent pre-stimulus low frequency power (± 1 SEM).

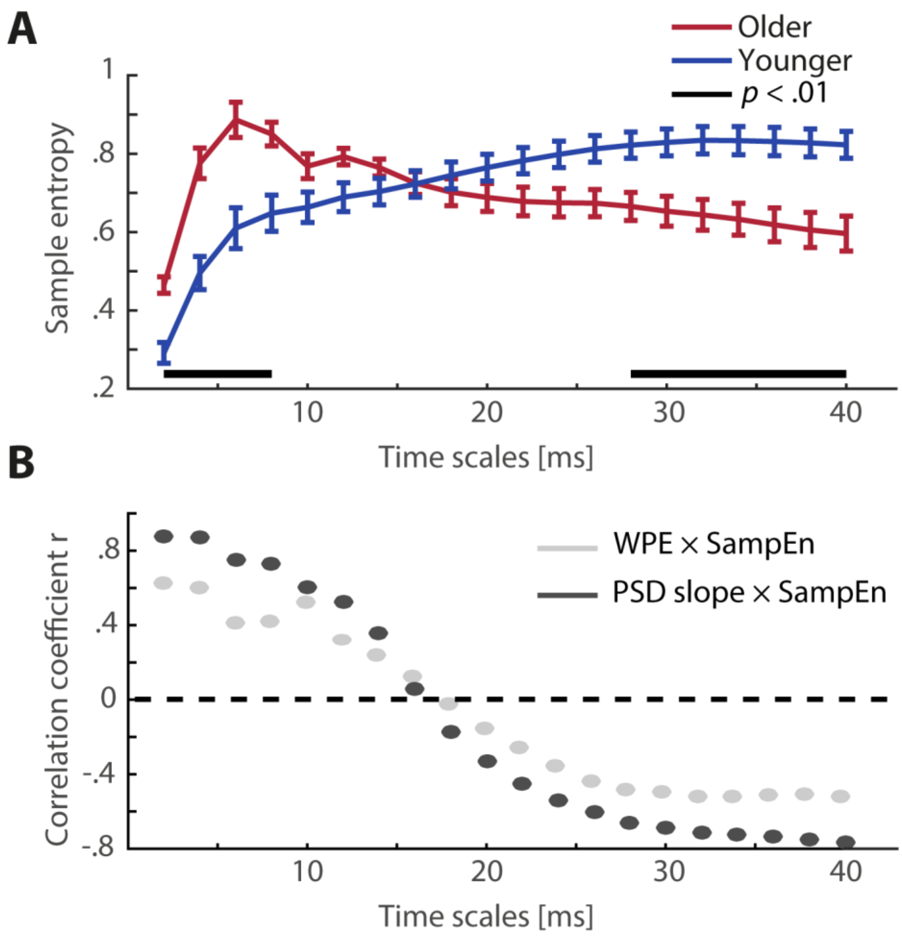

Figure S7. Multiscale entropy of different age groups and its relation to WPE and PSD slope. **A**, Sample entropy (SampEn, ±SEM) at different time-scales (x-axis) averaged for younger (blue) and older (red) participants (electrode Cz) is shown. Note that sample entropy at differnet time-scales is referred to as multi-scale entropy (MSE). Older participants exhibit higher entropy at finer time scales, a pattern that reverses at coarser time scales (see McIntosh et al., 2014; black bars $p < .01$). **B**, Sample entropy is correlated with average WPE and PSD slope. Whereas this correlation is positive for finer time scales, it switches its sign and is negative for coarser time scales (compare to **A**). The found increase of average WPE and the increased shallowness of PSD slopes with age (compare Fig. 3) thus likely captures processes at finer time scales.