

**Supplementary figure 1: Analysis of power spectral density of gamma oscillations**. Scatter plots showing the power spectral density (PSD) of gamma oscillations recorded from CA3 (upper panel) and CA1 (lower panel), during baseline, upon application of vehicle control (S-Lic 0) or S-Lic 300 µM, respectively, and washout. Each dot refers to one slice obtained from one animal; data are shown as mean ± standard deviation. Asterisks mark statistically significant differences as assessed by one-way ANOVA or Friedman test and Tukey´s or Dunnett´s *post hoc* test for multiple comparisons, respectively (*p*-value ≤ 0.05). *Kcnq2*+/+: S-Lic n = 8, vehicle control n = 5; *Kcnq2*+/- S-Lic n = 6, vehicle control n = 5.



**Supplementary figure 2: CA3-CA1 temporal relationship during gamma oscillations.** Analysis of S-Lic effects on temporal relationship between CA3 and CA1. **(A)** Delta phaseof gamma oscillations recorded simultaneously from CA3 and CA1, during application of vehicle control or S-Lic, respectively, and washout. n.s.: not significant differences as assessed by Uniform Score test for circular data. Data are shown as median ± interquartile range. **(B)** Scatter plot showing gamma z-transformed coefficients of cross-correlation between CA3 and CA1 during baseline, application of vehicle control or S-Lic, respectively, and washout. **(A, B)** Vehicle control (S-Lic 0): *Kcnq2*+/+ n = 5; *Kcnq2*+/- n = 5. S-Lic 300: *Kcnq2*+/+ n = 6; *Kcnq2*+/- n = 5. **(C)** Scatter plot of time lag between CA3 and CA1 during baseline, application of vehicle control or S-Lic, respectively, and washout. Vehicle control (S-Lic 0): *Kcnq2*+/+ n = 5; *Kcnq2*+/- n = 5. S-Lic 300: *Kcnq2*+/+ n = 5; *Kcnq2*+/- n = 5. **(B,C)** Data are shown as mean ± SD. Asterisks mark statistically significant differences as assessed by one-way ANOVA and Tukey´s *post hoc* test for multiple comparisons, respectively (*p*-value ≤ 0.05).