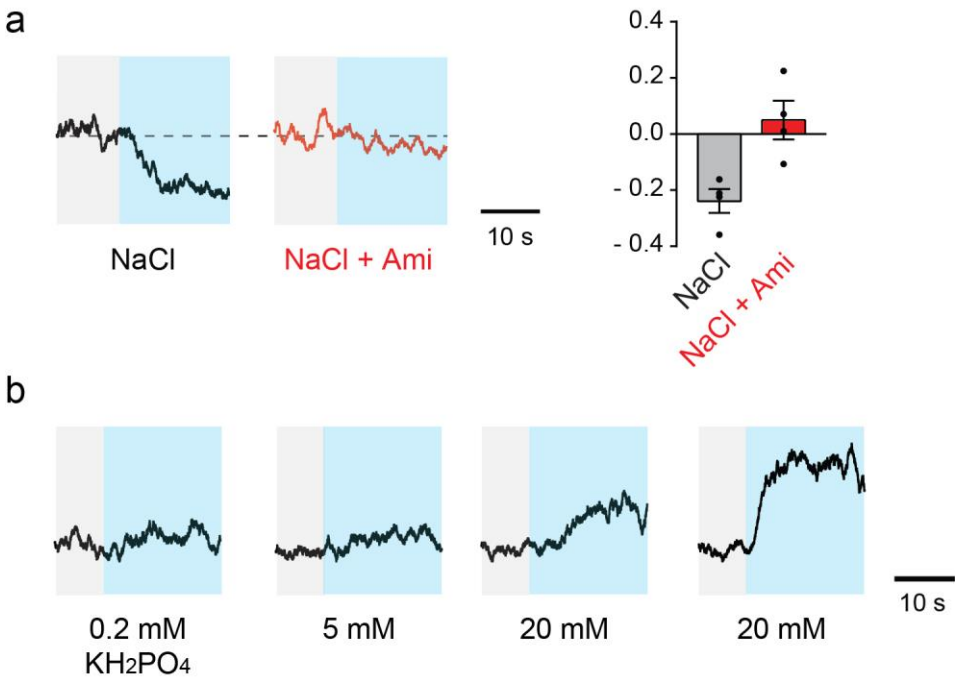
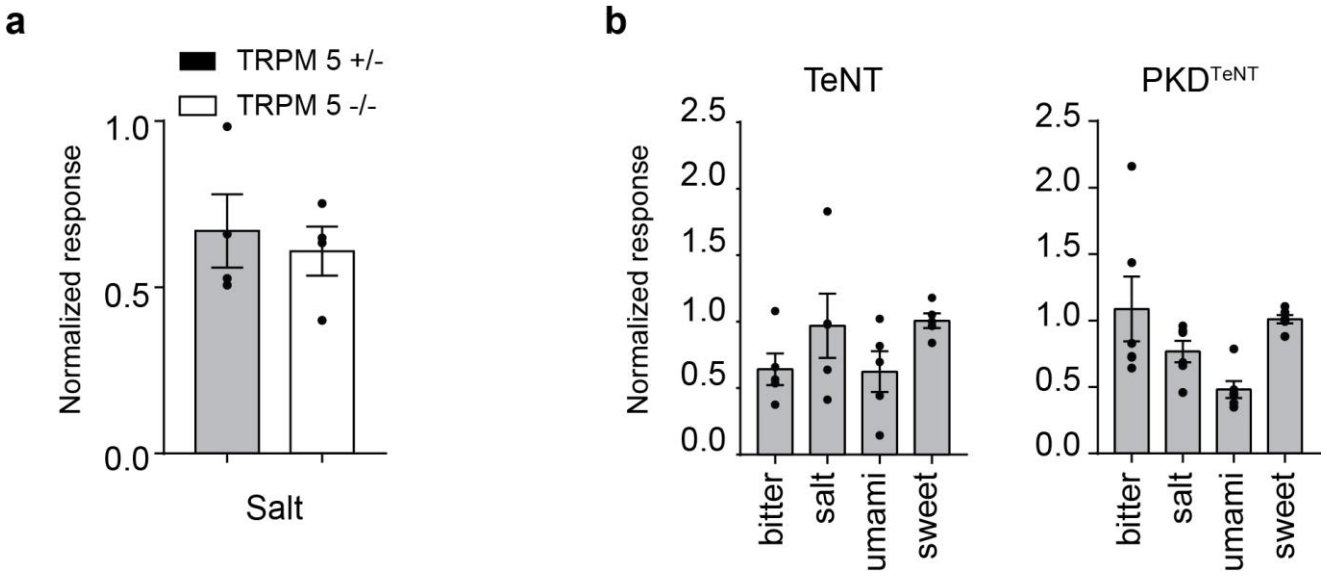


Supplementary Figure 1

Ionic effects on taste responses induced by water

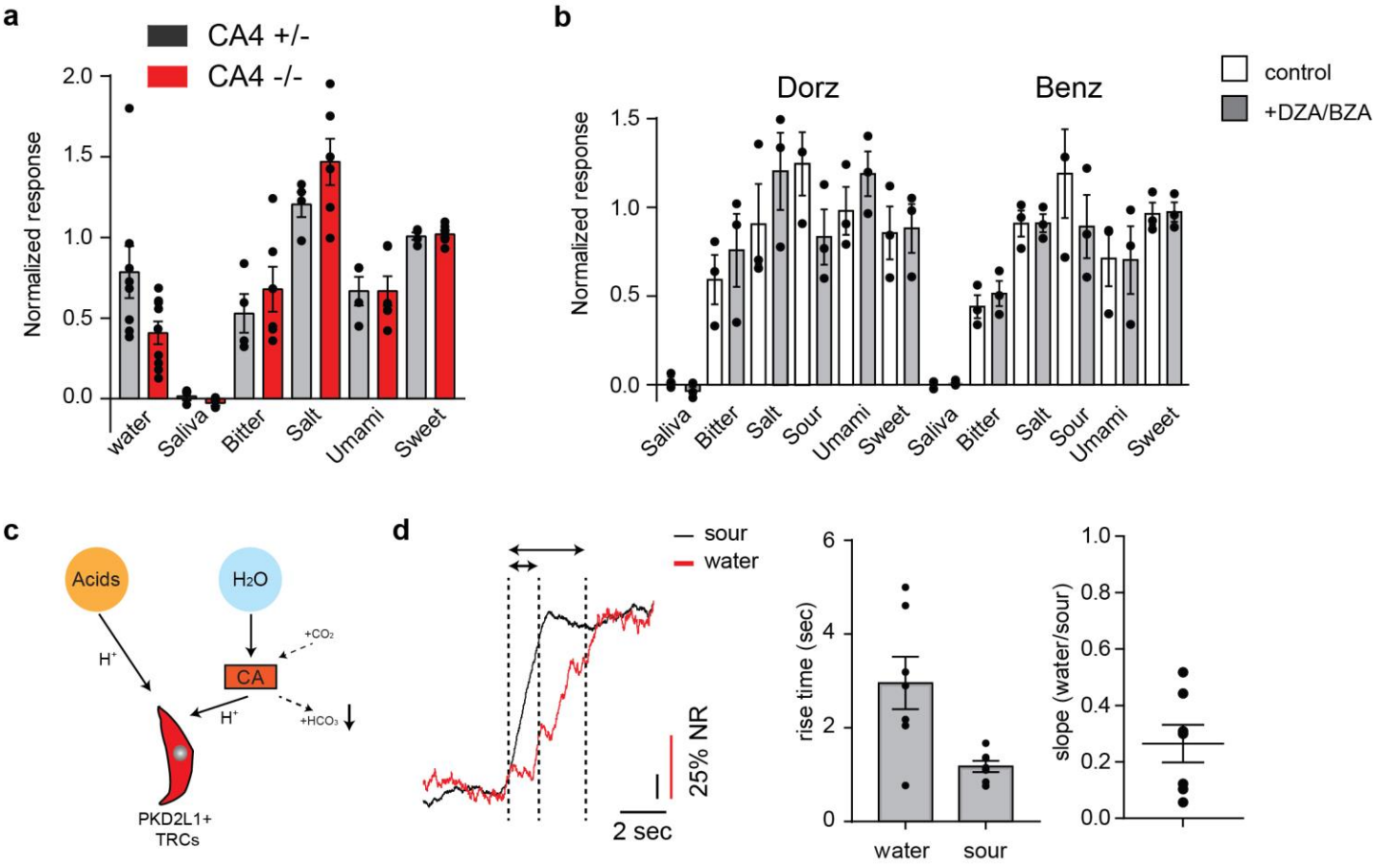
a, Effect of sodium ions on water responses. Representative traces of water responses after NaCl are shown in the presence or absence of amiloride (Ami), a blocker of the epithelium sodium channel (left). A reduction of nerve firing by the removal of NaCl is completely blocked by amiloride, suggesting that this change is mediated by the sodium taste receptor. Quantified nerve responses are shown (n=4 for NaCl + Ami). The data for NaCl alone is from Figure 1b for reference. **b**, Representative water responses induced by the removal of phosphate ions. In addition to bicarbonate ions, washing out of high concentrations of phosphate (KH_2PO_4) induced minor responses.



Supplementary Figure 2

Taste responses in *Trpm5*$^{-/-}$ and *Pdk2l1*^{TeNT} mice

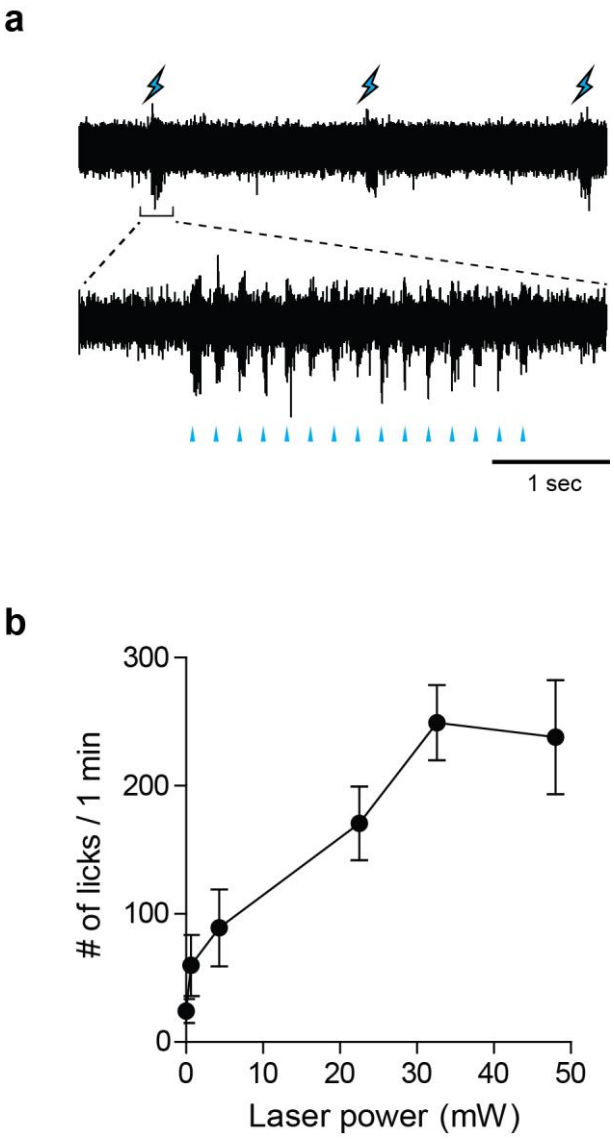
a, Knocking out of TRPM5 has no effect on salt and sour responses. Nerve responses to salt (60 mM NaCl) in *TRPM5 -/-* mice were comparable to those in *TRPM5 +/-* control mice (n=4 for *TRPM5 -/-* and n=4 for *TRPM5 +/-*). Responses were normalized to 10 mM Citric Acid. **b**, Sour and water responses were specifically disrupted in PKD^{TeNT} mice. However, response amplitudes to bitter (0.1 mM cycloheximide), salt (60 mM NaCl), umami (50 mM MPG + 1 mM IMP), and sweet (8 mM AceK) were similar between PKD^{TeNT} (n=6) and TeNT control mice (n=5). Responses were normalized to 8 mM AceK. Data were analyzed with two-tailed Mann-Whitney U-test. Values are means ± s.e.m



Supplementary Figure 3

Carbonic anhydrase–independent taste responses and the kinetics of PKD2L1 taste responses

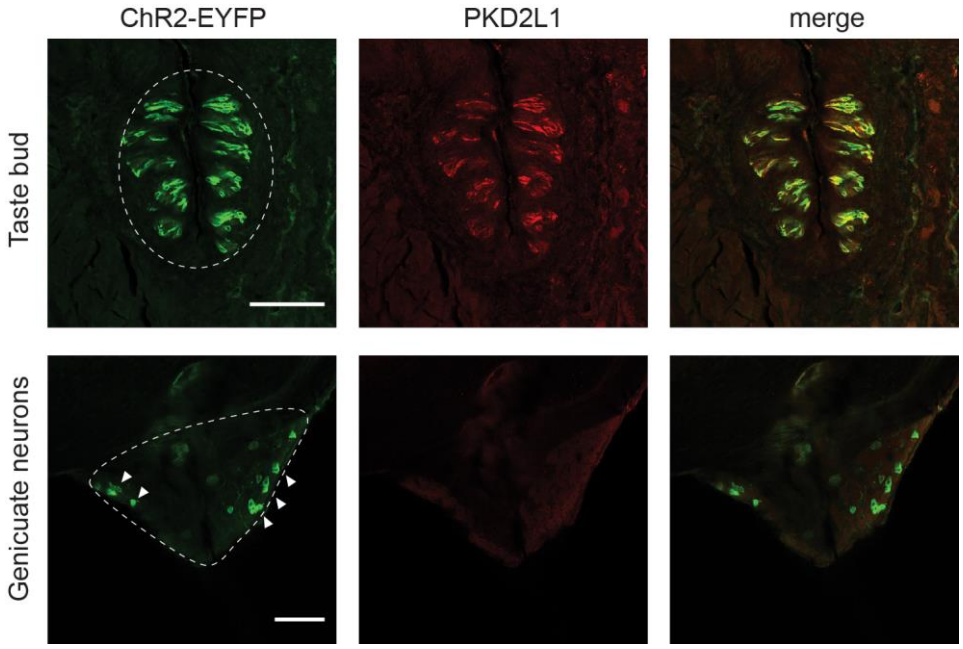
a, CA4 knockout mice exhibit significantly reduced responses to non-buffered water (n=9 for CA4 -/-, n=8 for CA4 -/+; p=0.0464). All other tastants evoked similar response magnitudes in both genotypes (n=6 for CA4 -/-, n=4 for CA4 +/-). **b,** Treatments with dorzolamide (DZA) or benzolamide (BZA) had no effect on basic taste responses (n=3). **c,** A proposed model for activation of acid-sensing TRCs by water and sour. Acids (protons) directly activate PKD2L1-expressing TRCs through putative proton/potassium channels [45]. On the other hand, washing out of bicarbonate with water drives catalytic reaction of CA in PKD2L1-expressing TRCs, leading to increase in local protons. **d,** Representative taste nerve responses to water and citric acid from the same animal (left). Response rise time (n=7, p=0.0157, middle), and ratio of the rising slopes (right) show slower kinetics of water responses compared to citric acid. Data were analyzed with two-tailed paired t-test. Values are means ± s.e.m



Supplementary Figure 4

Light-induced taste nerve responses in *Pdk2l1*^{ChR2} mice

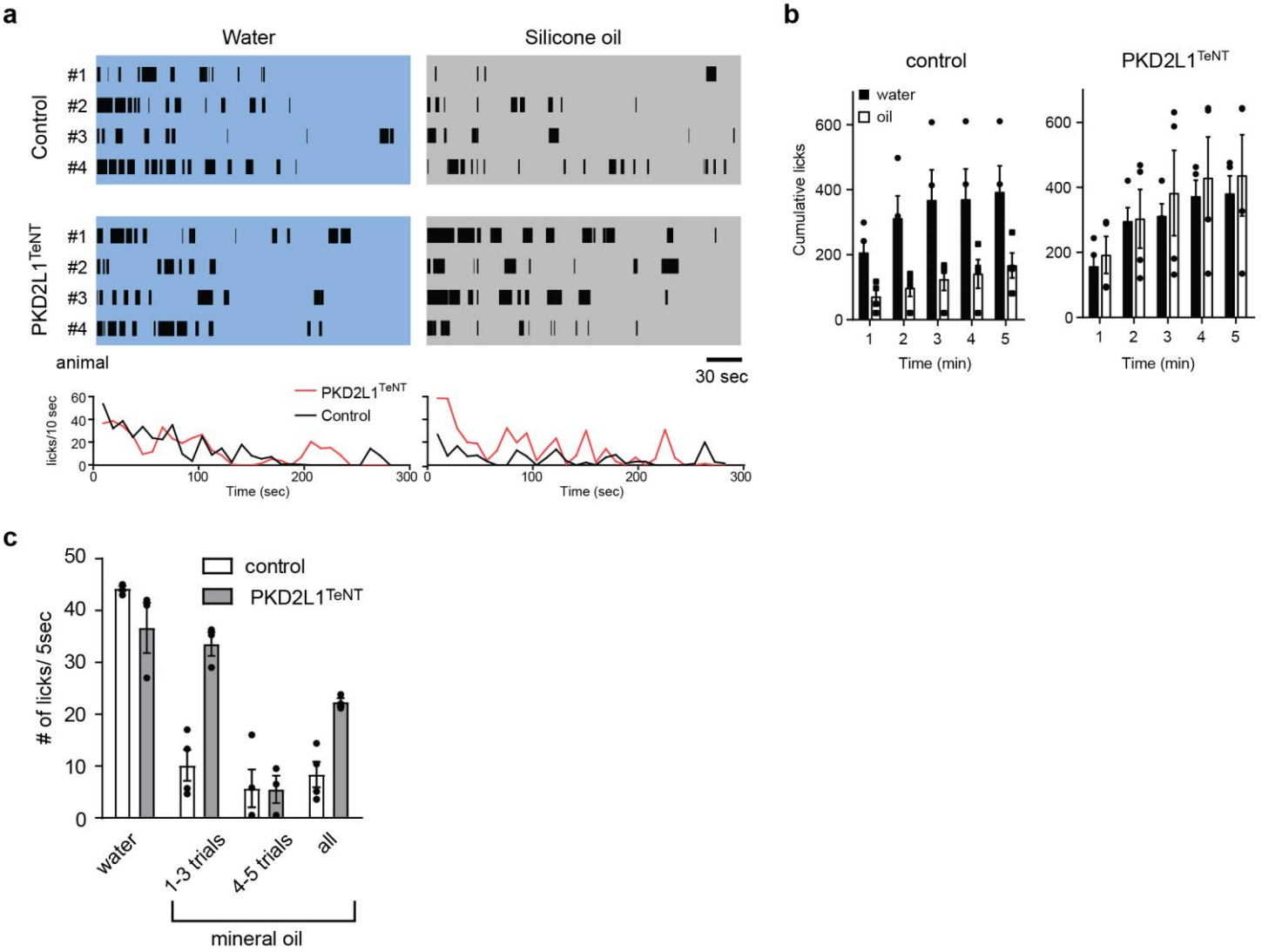
a, The tongue was stimulated with laser pulses (8 Hz, 40 ms duration) at 48 mW for 2 s. Shown is a representative trace of three sets of pulse trains. Inset shows a magnified view of a 2-s stimulation window. Each blue triangle corresponds to a laser pulse. An increase in population activity in the nerve is precisely time-locked to laser pulses. **b**, Total number of licks induced by different levels of laser power. The number of licks was summed during a 1-min session (n=5). Each data point was obtained and averaged from three PKD2L1^{ChR2} animals. Values are means ± s.e.m.



Supplementary Figure 5

Ectopic expression of ChR2-EYFP in the geniculate ganglion

Tissue staining of taste buds in the circumvallate papillae (top), and geniculate ganglion (secondary taste station, bottom) from a PKD2L1^{ChR2} animal. Shown are representative staining of ChR2-EYFP (labeled with anti-GFP antibody, left), co-labeled with anti-PKD2L1 antibody (middle); the right panels show merged images. ChR2-EYFP signals overlap with PKD2L1 expression in taste buds (top panel). However, ectopic expressions of ChR2-EYFP in geniculate neurons (arrow heads, bottom left) do not show PKD2L1 expression (bottom middle). Scale bars, 100 μm.



Supplementary Figure 6

Acid-sensing TRCs are important for fluid discrimination, but not for water consumption

a, Plots of drinking behavior of PKD2L1^{TeNT} and control mice during 5-min consumption tests. Either water or silicone oil was presented to each animal for 5 min after 23 h water-deprivation regime. Individual black bars indicate each lick event. Average number of licks are quantified for each 10-sec period (bottom). **b,** Cumulative number of licks is shown during the 5-min sessions (n=4, p=0.0188 at 5 min). **c,** A role of taste pathway for discriminating water and mineral oil. To test if animals can discriminate water and mineral oil, water was first presented to water-deprived animals for 5 s (water), followed by 5 consecutive presentations of mineral oils (5 s each, 1-5 trials). Consistent with the results of silicone oil, PKD2L1^{TeNT} initially consumed comparable amount of mineral oil to water (1-3 trials), but animals learned to discriminate in later trials (4-5 trials, n=3, p=0.0467, water vs 4-5 trials) possibly using other sensory cues such as olfaction and tactile. By contrast, control (TeNT) mice preferred water over mineral oil throughout the trials (n=4, p=0.0012, water vs 1-3 trials, p=0.0007, water vs all). Data were analyzed with two-tailed paired t-test. Values are means ± s.e.m